US009044692B2

(12) **United States Patent**
Rock

(10) **Patent No.: US 9,044,692 B2**
(45) **Date of Patent: *Jun. 2, 2015**

(54) **SYSTEMS AND METHODS FOR WATER DESALINIZATION**

(75) Inventor: **Kelly P. Rock**, Vienna, VA (US)

(73) Assignee: **Micronic Technologies, Inc.**, Wise, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 588 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/217,720**

(22) Filed: **Aug. 25, 2011**

(65) **Prior Publication Data**

US 2011/0309162 A1 Dec. 22, 2011

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/636,527, filed on Dec. 11, 2009, now Pat. No. 8,273,165.

(51) **Int. Cl.**

B01D 53/14	(2006.01)
B01D 1/14	(2006.01)
B01D 1/16	(2006.01)
B01D 1/20	(2006.01)
B01D 1/30	(2006.01)
B01D 5/00	(2006.01)
C02F 1/04	(2006.01)
C02F 1/12	(2006.01)
C02F 103/08	(2006.01)

(52) **U.S. Cl.**

CPC .. ***B01D 1/14*** (2013.01); ***B01D 1/16*** (2013.01); ***B01D 1/20*** (2013.01); ***B01D 1/30*** (2013.01); ***B01D 5/0003*** (2013.01); ***B01D 5/006*** (2013.01); ***C02F 1/04*** (2013.01); *C02F 1/12* (2013.01); *C02F 2103/08* (2013.01)

(58) **Field of Classification Search**

CPC B01D 1/14; B01D 1/30; B01D 5/006; B01D 1/20; B01D 1/16; B01D 5/0003; C02F 1/04; C02F 2103/08; C02F 1/12

USPC 55/345, 343, 346, 347, 459.1; 96/208, 96/209, 351, 352; 210/180, 221.2, 188, 210/218, 220, 512.1; 261/78.2, 79.2, 116

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,649,468	A	3/1972	Bechard et al.
3,837,491	A	9/1974	Humiston et al.

(Continued)

FOREIGN PATENT DOCUMENTS

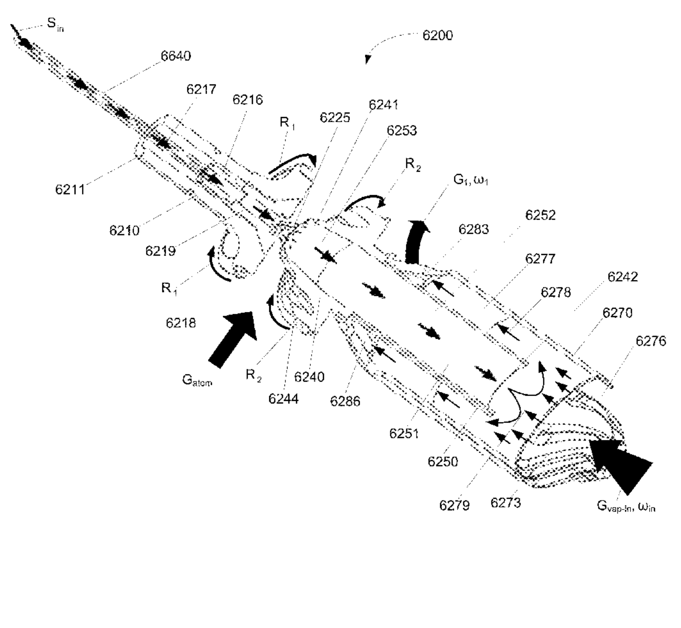
WO	WO 2007/133771	A2	11/2007

Primary Examiner — Dung H Bui
(74) *Attorney, Agent, or Firm* — Cooley LLP

(57) **ABSTRACT**

An apparatus includes a set of atomizers, a housing and a separator. Each atomizer includes an inlet portion that receives an inlet flow of a solution and an outlet portion that produces an atomized flow of the solution. The housing defines a flow path. Each atomizer is disposed at least partially within the housing such that the outlet portion of each atomizer is in fluid communication with the flow path. The housing is configured such that a gas flowing within the flow path can be sequentially mixed with the atomized flow of the solution produced by the outlet portion of each atomizer to produce a mixture of the gas and the solution. The separator produces a first outlet flow including a portion of the gas and a vaporized portion of a solvent, and a second outlet flow including a liquid portion of the solvent and a solute.

11 Claims, 47 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,176,779	A	12/1979	Kirk et al.	
4,515,734	A	5/1985	Rock et al.	
4,568,500	A	2/1986	Rock et al.	
4,595,459	A	6/1986	Kusakawa et al.	
5,078,880	A	1/1992	Barry	
5,176,799	A	1/1993	Roe et al.	
5,472,645	A	12/1995	Rock et al.	
5,534,118	A	7/1996	McCutchen	
5,620,561	A	4/1997	Kuhn et al.	
5,672,187	A	9/1997	Rock et al.	
5,744,008	A	4/1998	Craven	
6,110,368	A	8/2000	Hopkins et al.	
6,113,078	A	9/2000	Rock	
6,234,459	B1	5/2001	Rock	
6,244,573	B1	6/2001	Rock	
6,293,121	B1	9/2001	Labrador	
6,347,789	B1	2/2002	Rock	
6,500,216	B1	12/2002	Takayasu	
6,648,306	B2	11/2003	Rock	
6,669,176	B2	12/2003	Rock	
6,811,690	B2	11/2004	Arnaud	
6,973,792	B2	12/2005	Hicks	
7,681,569	B2	3/2010	Rock	
7,897,019	B2	3/2011	Akers	
8,273,165	B2	9/2012	Rock	
2007/0169773	A1 *	7/2007	Rock	128/200.14
2007/0204839	A1	9/2007	Rock et al.	
2008/0083605	A1	4/2008	Holtzapple et al.	
2010/0038229	A1	2/2010	Nadeau, Jr. et al.	
2010/0065510	A1	3/2010	Krichtafovitch et al.	
2011/0139697	A1 *	6/2011	Rock	210/180
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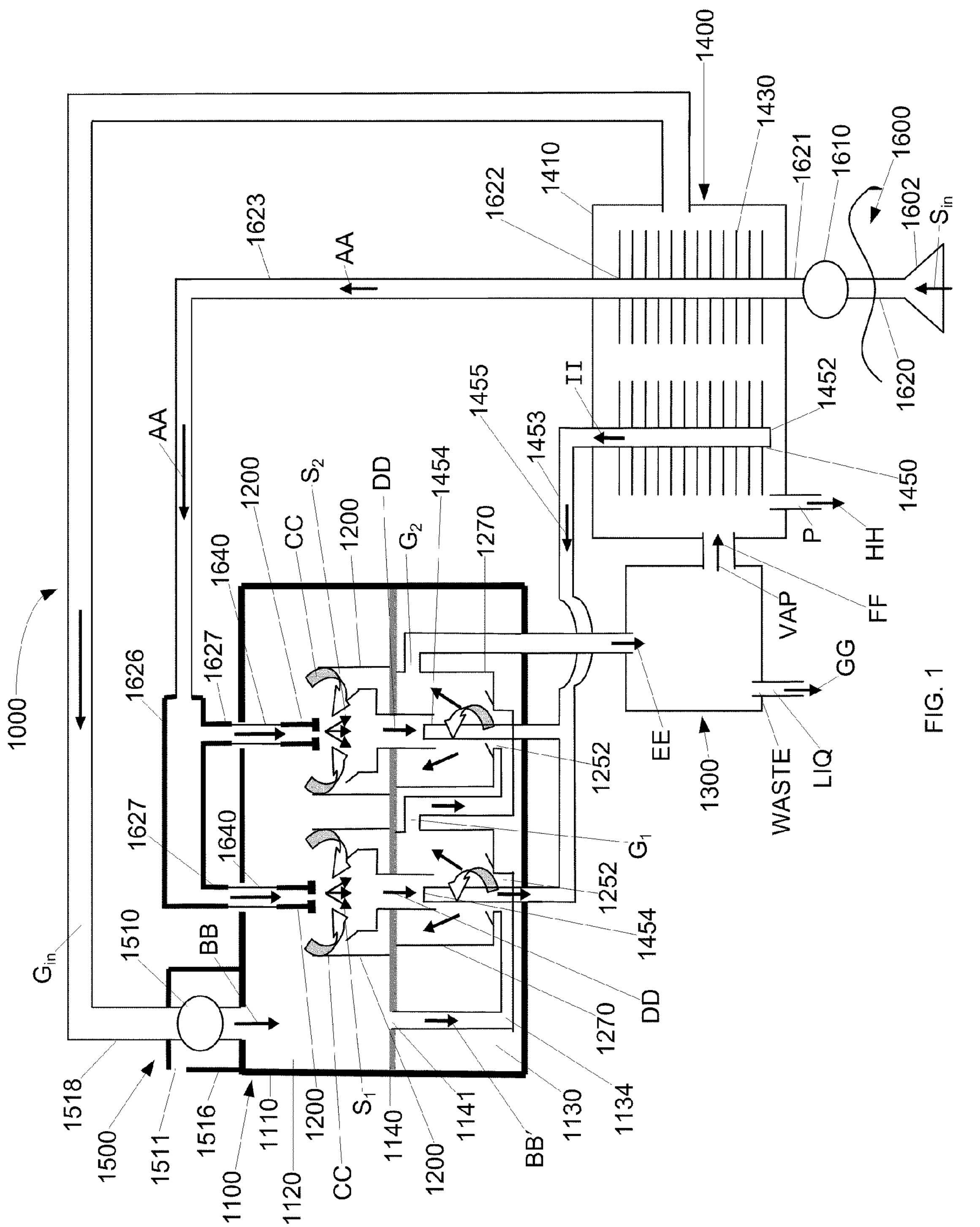
2014/0034478	A1	2/2014	Rock	

* cited by examiner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1410
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1623
AA
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1610
1600
1602
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1620
1452
1450
II
1455
1453
P
HH
VAP
FF
GG
LIQ
WASTE
1300
EE
AA
1200
S_2
CC
1200
DD
1454
G_2
1270
1640
1627
1626
1252
G_1
1252
1454
1627
1640
1510
BB
G_{in}
1518
1500
1511
1516
1100
1110
1120
1200
S_1
CC
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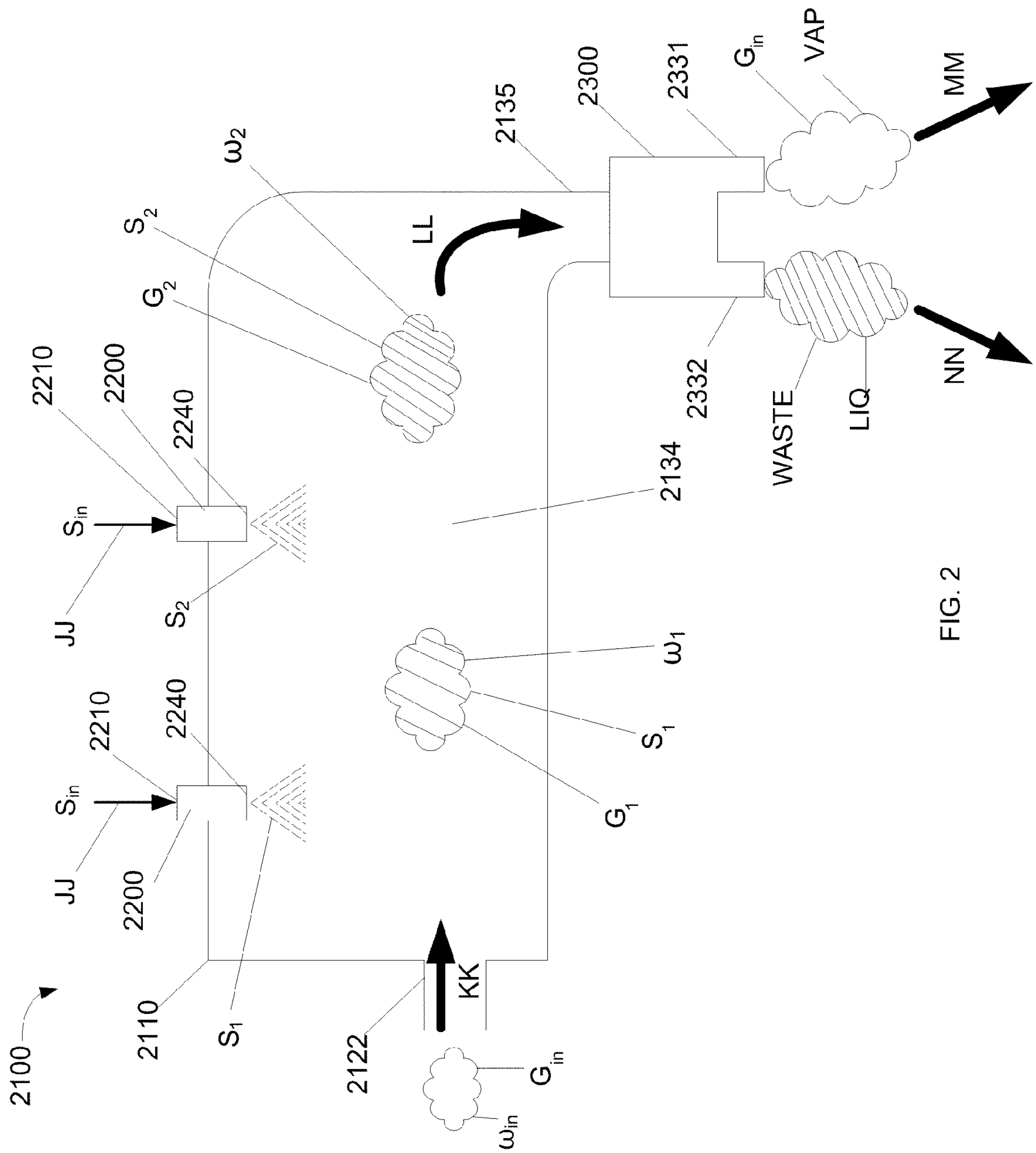
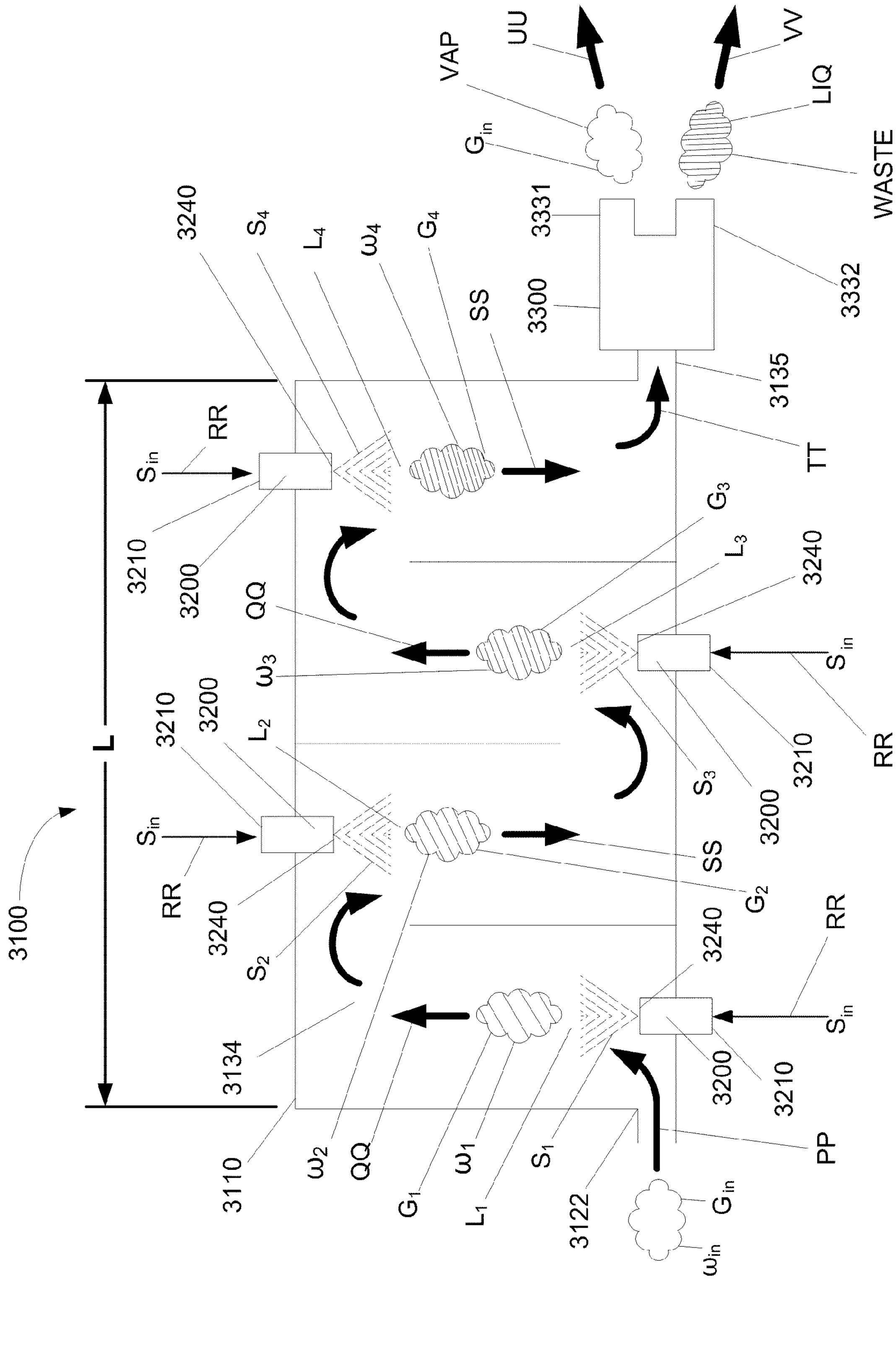
1200
1141
BB
1130
1134
1270
DD

FIG. 1



2100
2110
S_1
2122
G_{in}
ω_{in}
KK
JJ
2200
S_{in}
2210
2240
S_2
2134
ω_1
S_1
G_1
G_2
S_2
ω_2
LL
2135
2300
2331
G_{in}
VAP
MM
2332
WASTE
LIQ
NN

FIG. 2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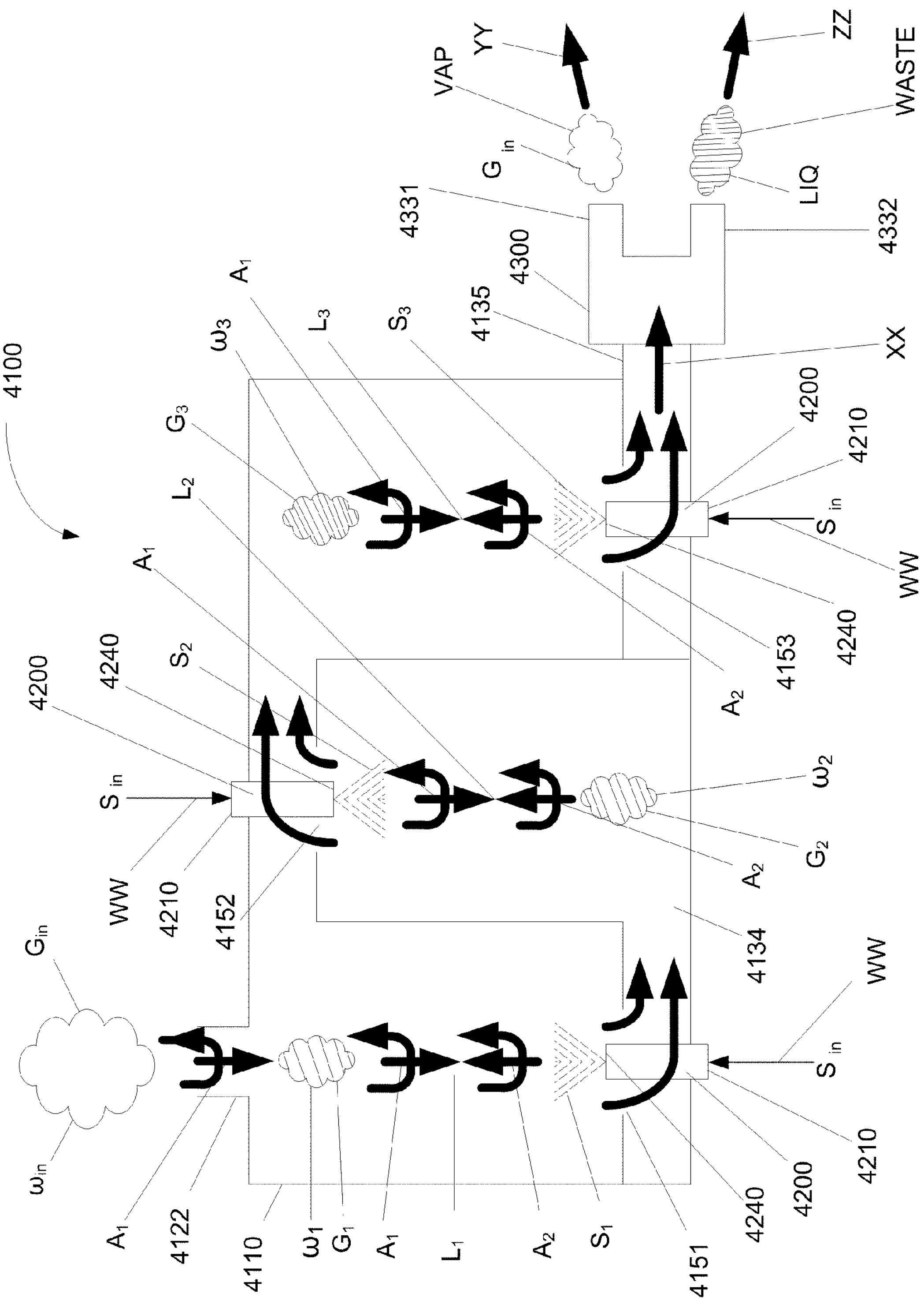
L
3110
3122
3134
3135
3200
3210
3240
3300
3331
3332
G_{in}
ω_{in}
S_{in}
G_1
G_2
G_3
G_4
L_1
L_2
L_3
L_4
S_1
S_2
S_3
S_4
ω_1
ω_2
ω_3
ω_4
PP
QQ
RR
SS
TT
UU
VV
VAP
LIQ
WASTE

FIG. 3



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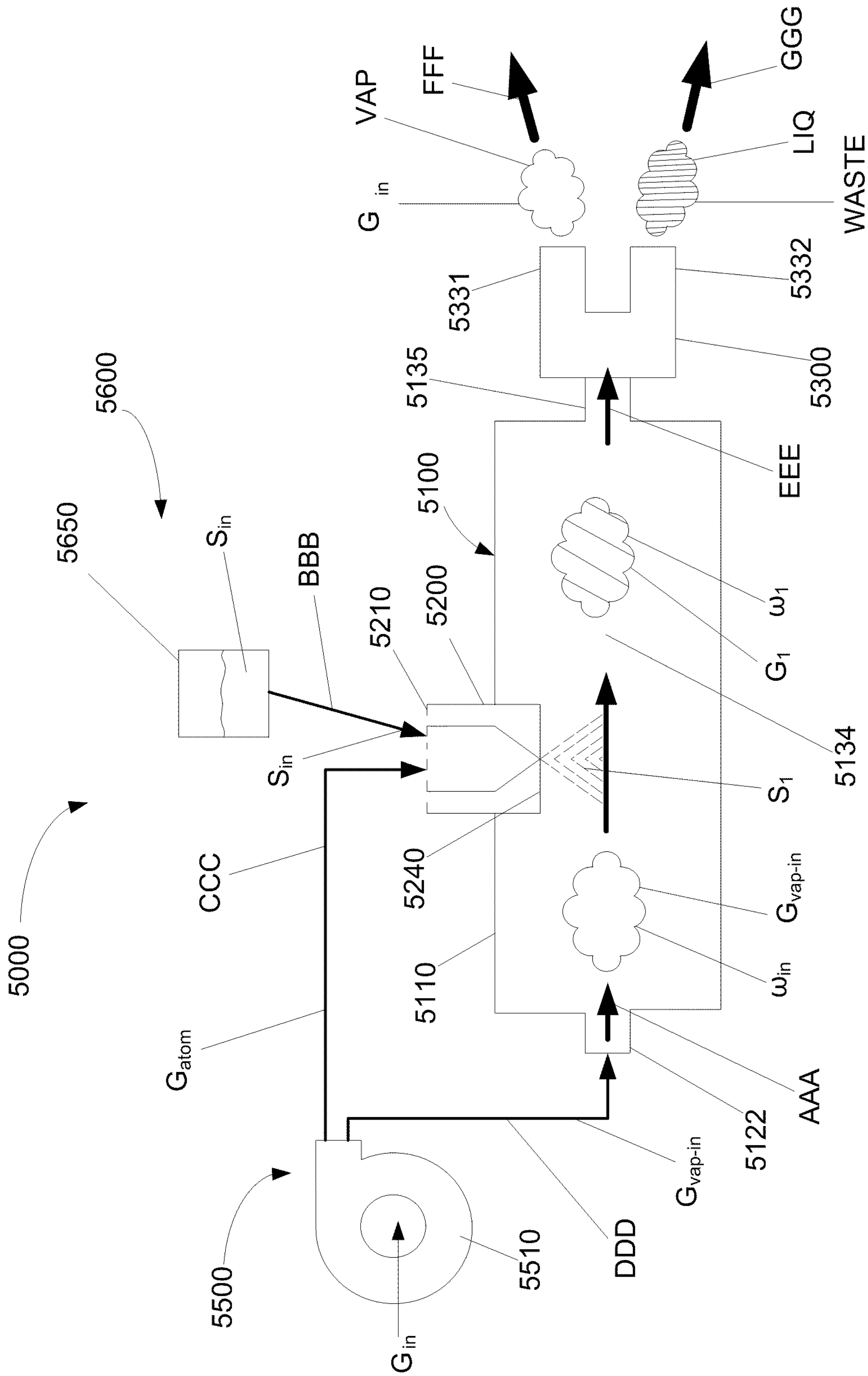
VAP
YY
ZZ
WASTE
G in
LIQ
4331
4332
4300
4135
XX
A1
L3
S3
ω3
G3
4200
4210
S in
WW
4240
4153
A2
L2
A1
S2
4240
4200
S in
WW
4210
4152
ω2
G2
A2
4134
Gin
ωin
A1
4122
4110
ω1
G1
A1
L1
A2
S1
4151
4240
4200
4210
S in
WW

FIG. 4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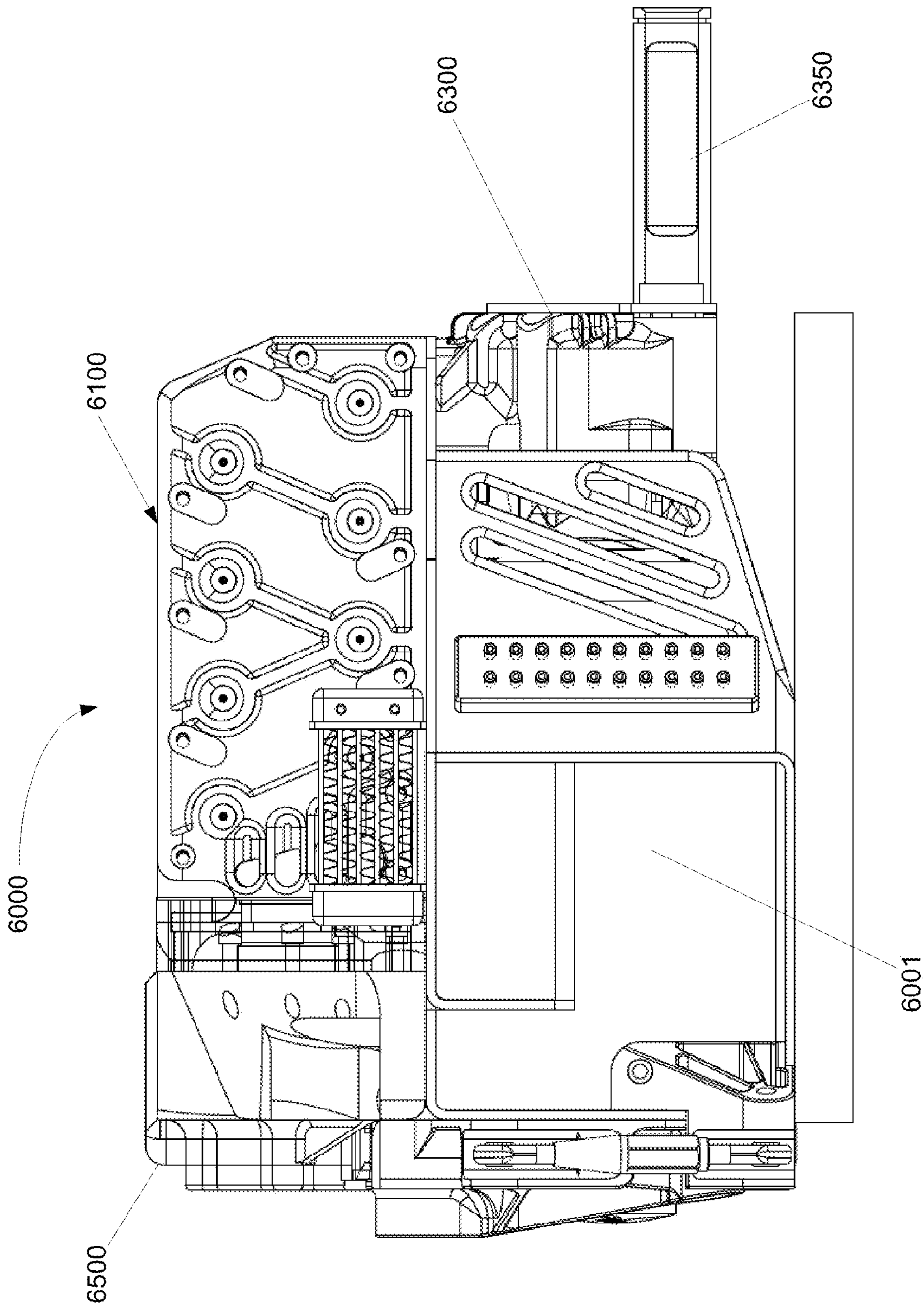
5650
S_{in}
BBB
5210
5200
5100
5135
5300
5331
5332
G_{in}
VAP
FFF
GGG
LIQ
WASTE
EEE
ω_1
G_1
5134
S_1
S_{in}
5240
CCC
G_{atom}
5110
G_{vap-in}
ω_{in}
AAA
5122
G_{vap-in}
DDD
5510
5500
G_{in}

FIG. 5



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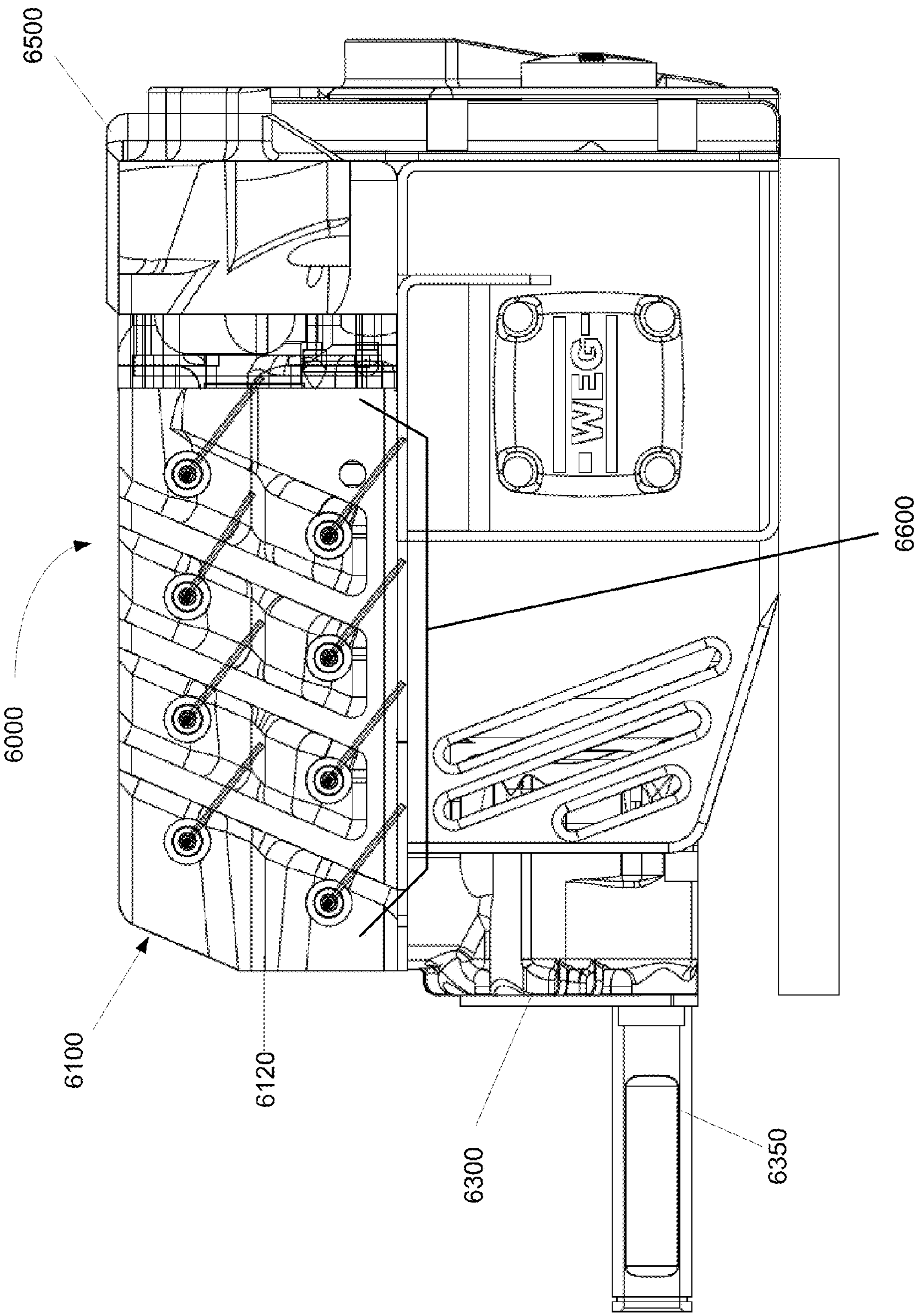

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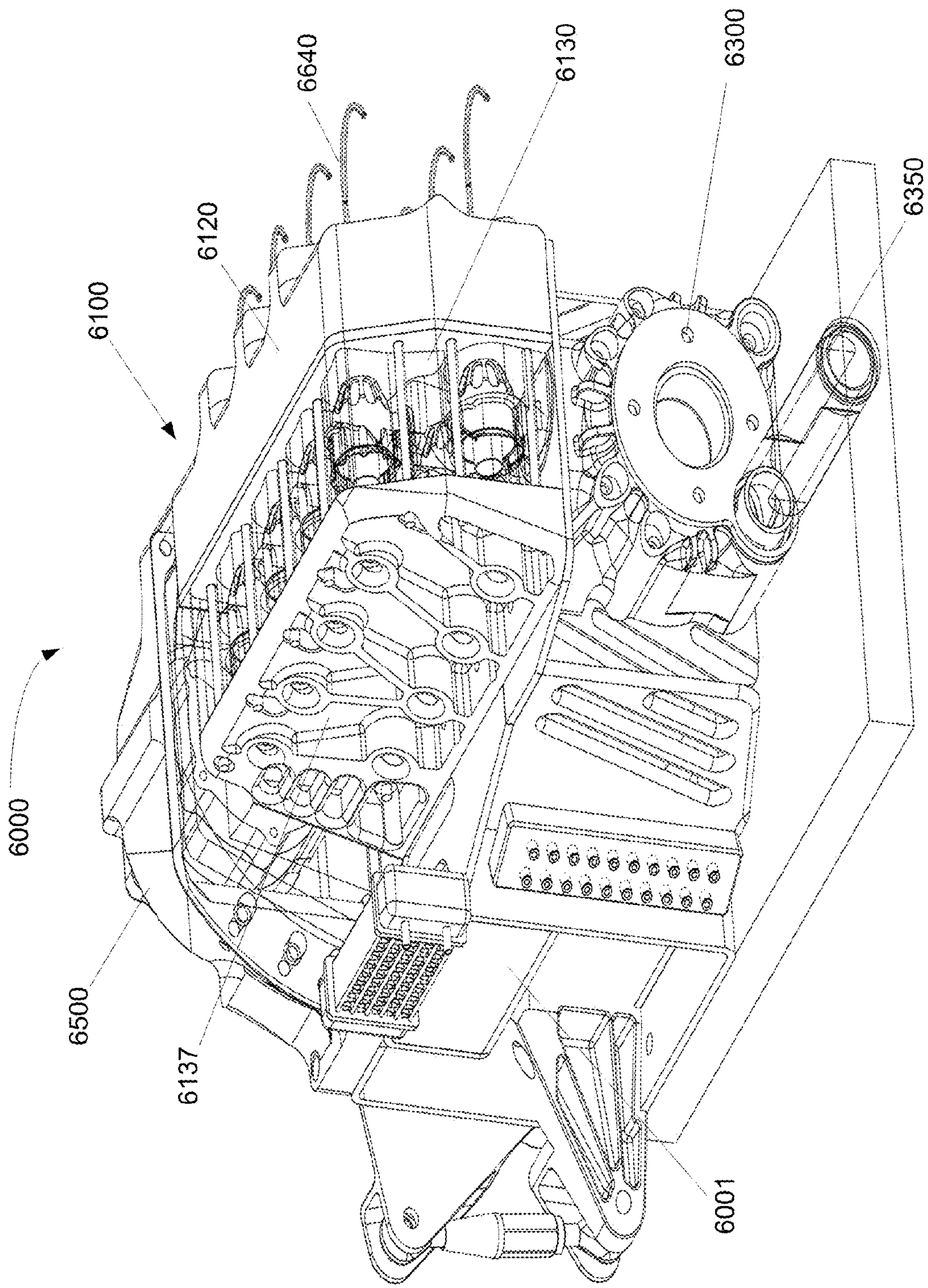


FIG. 8

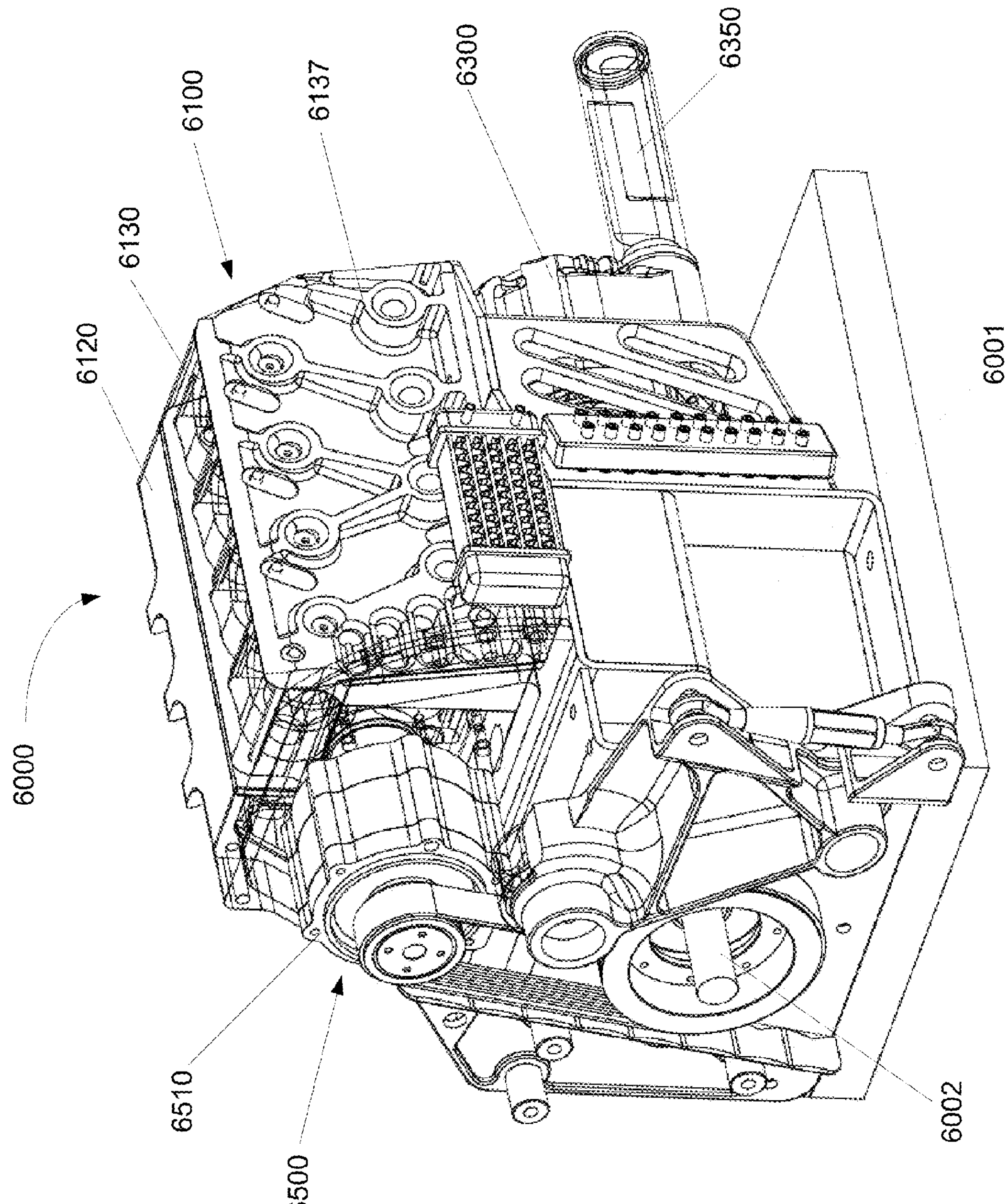
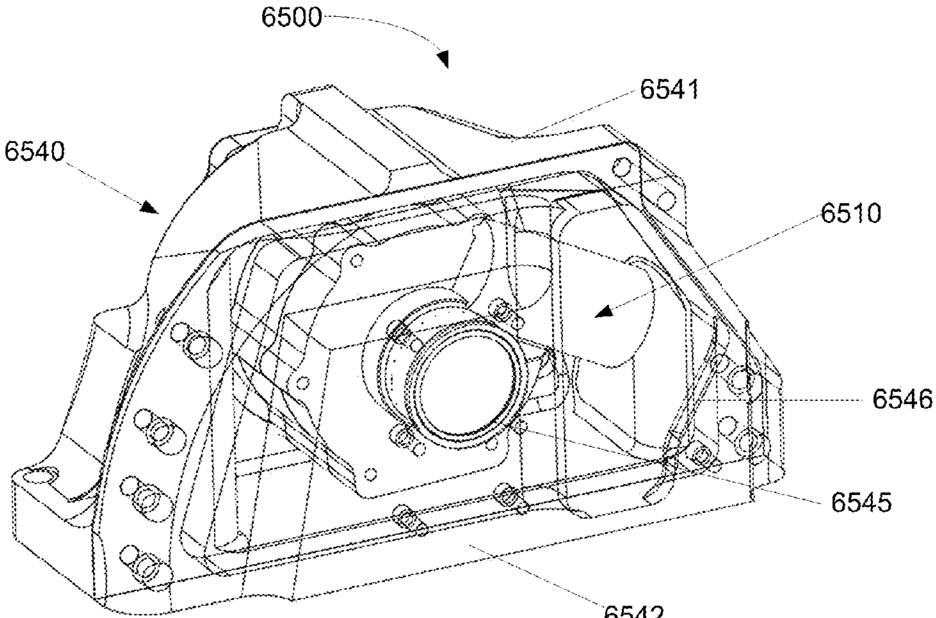


FIG. 9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6545
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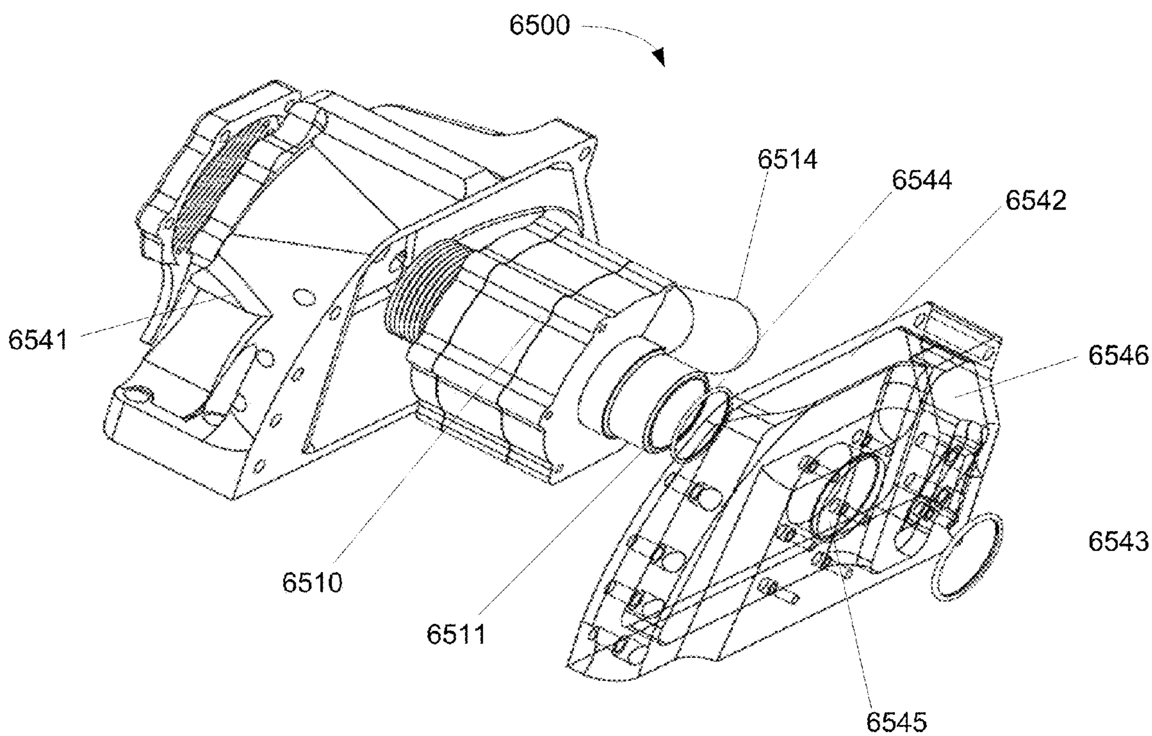
FIG. 10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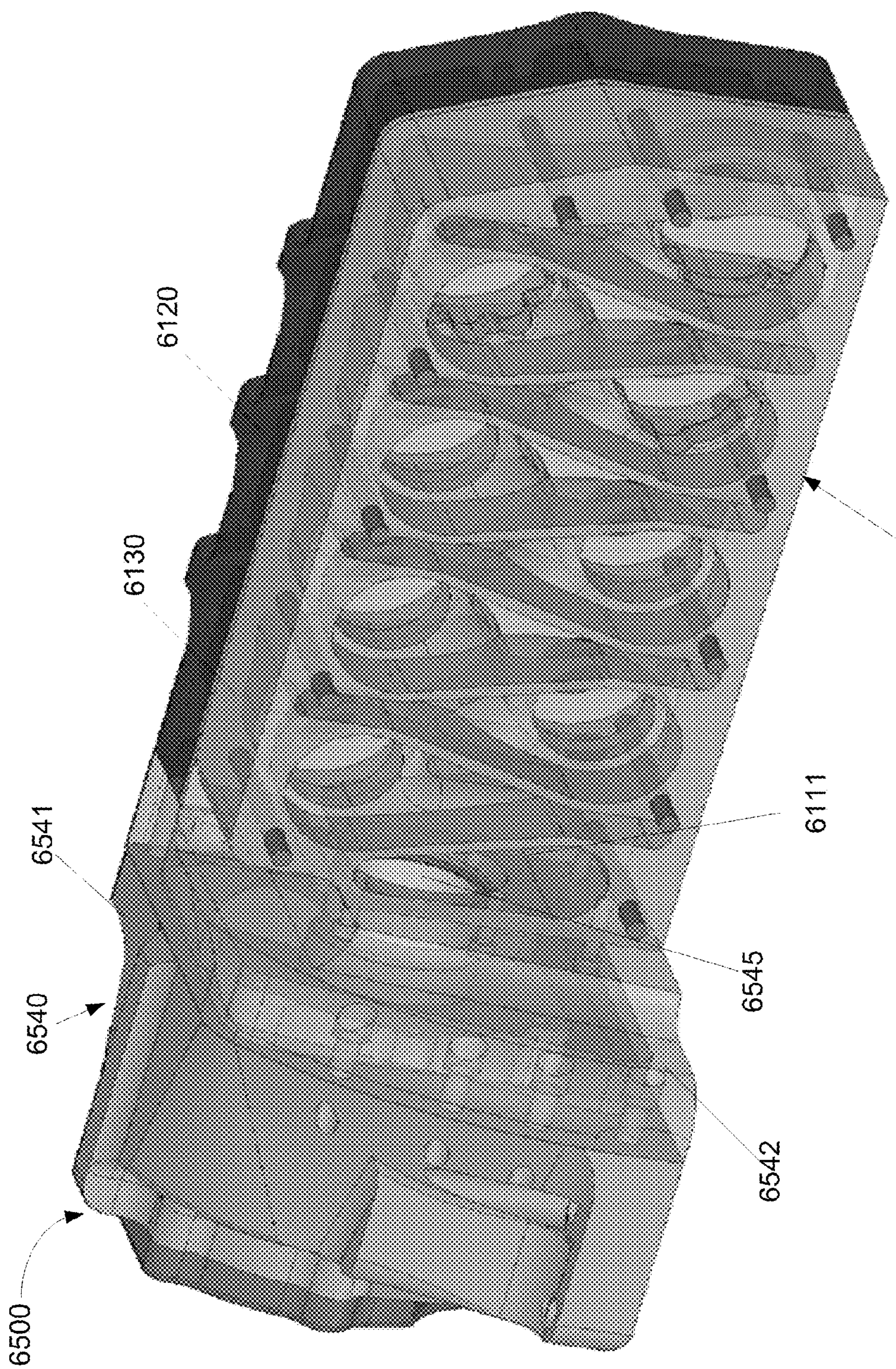
6543
6510
6511
6545

FIG. 11



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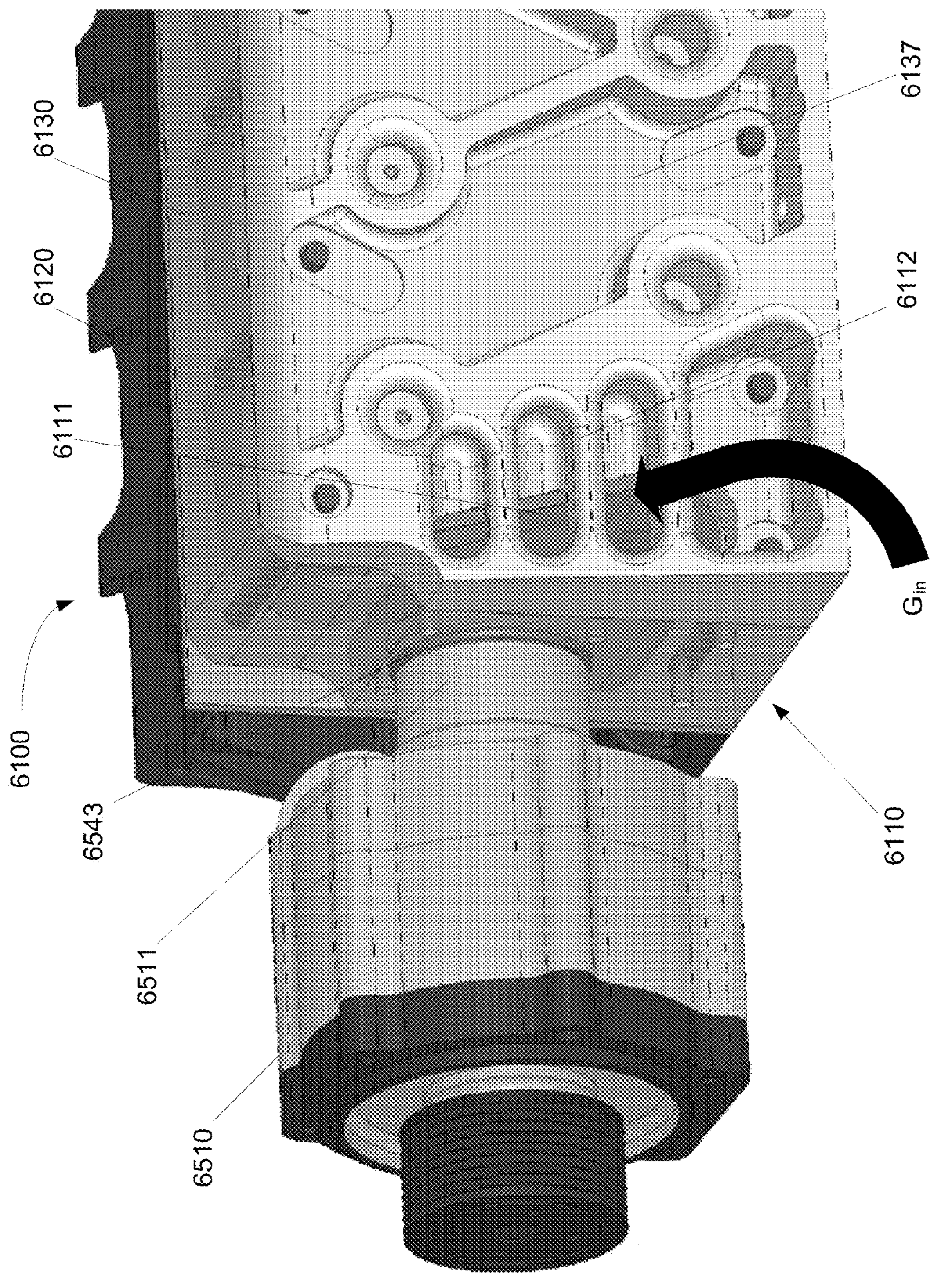

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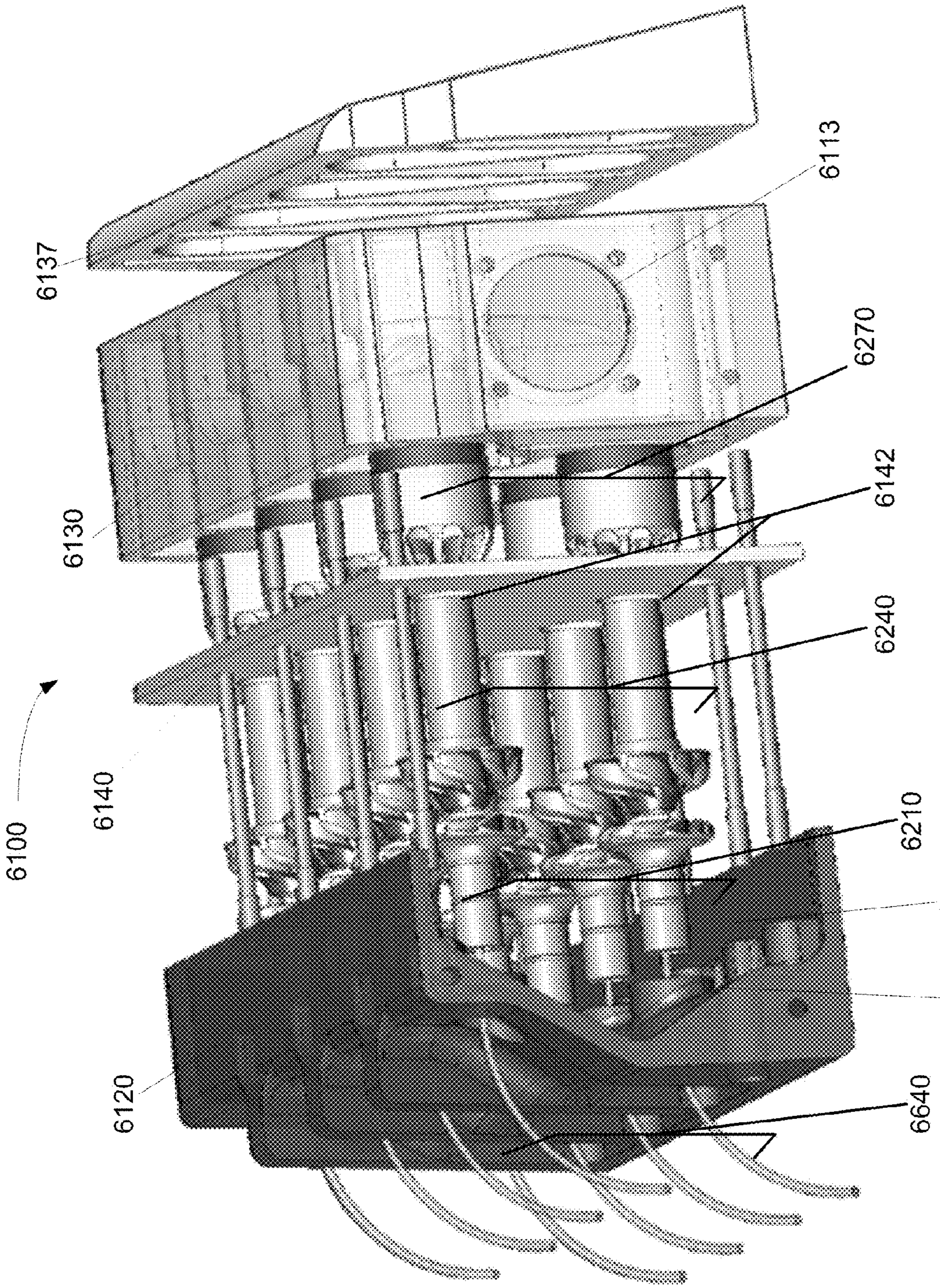
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6100
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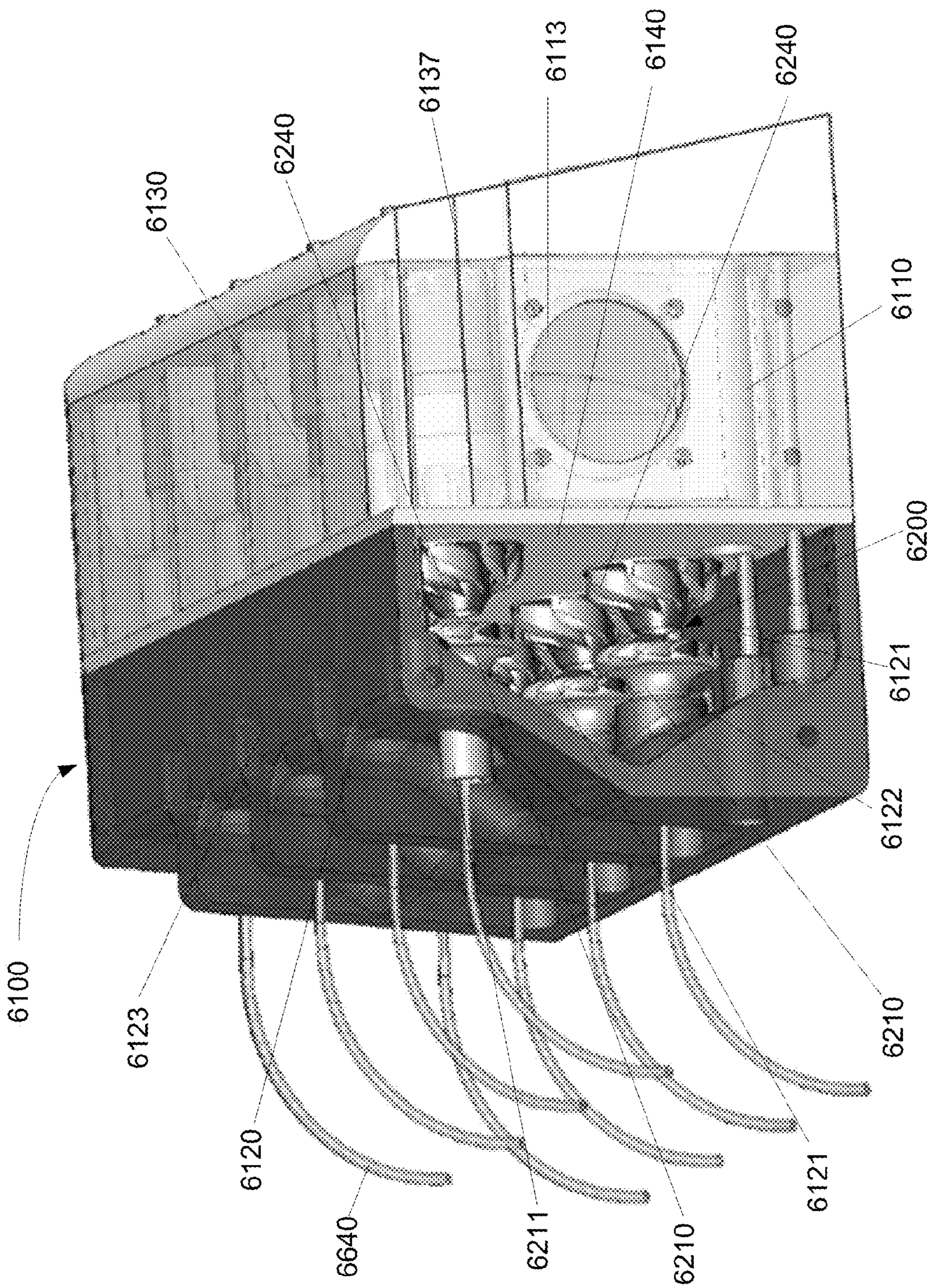
6210
6121
6122
6120
6640

FIG. 14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6240
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6121
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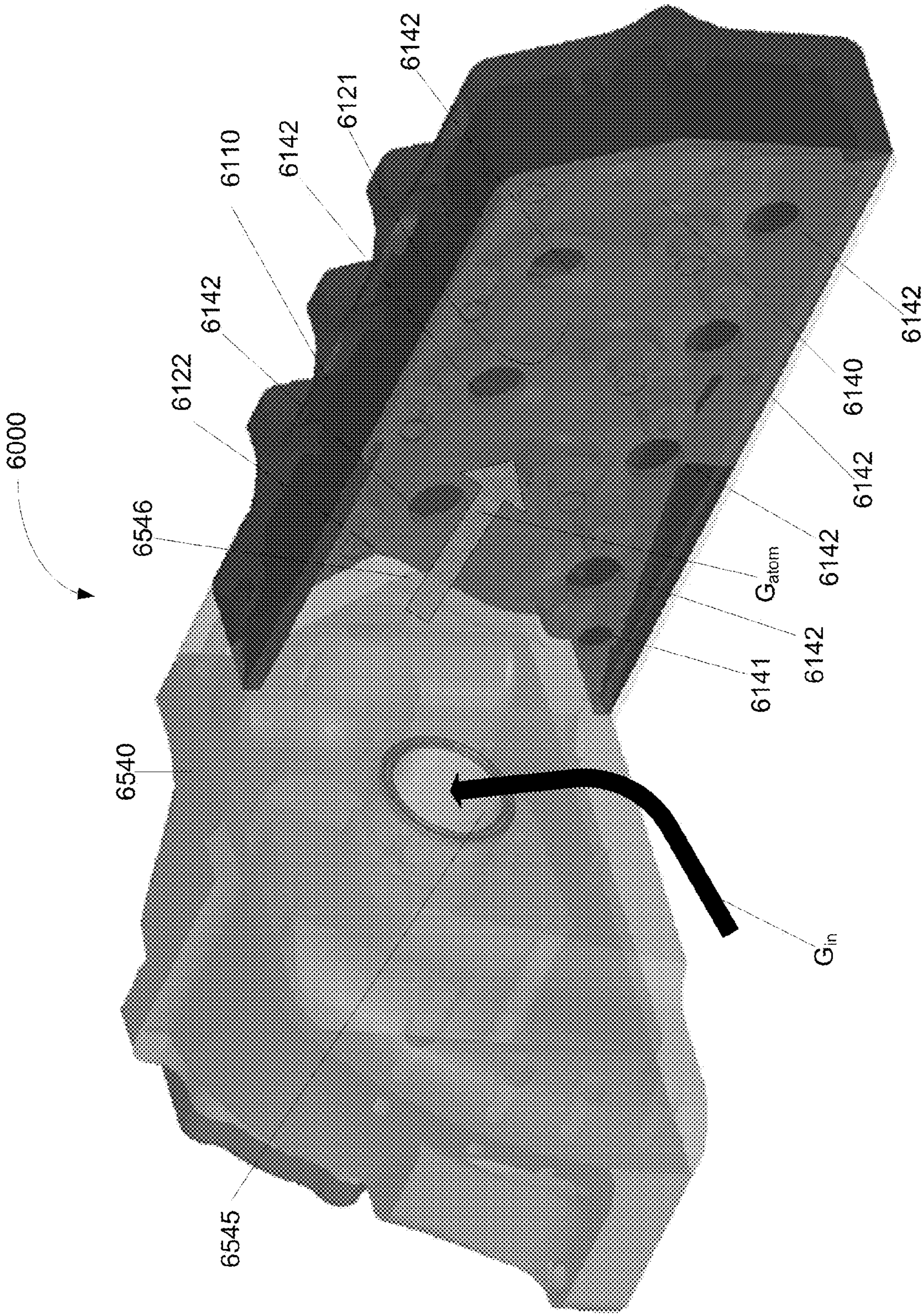
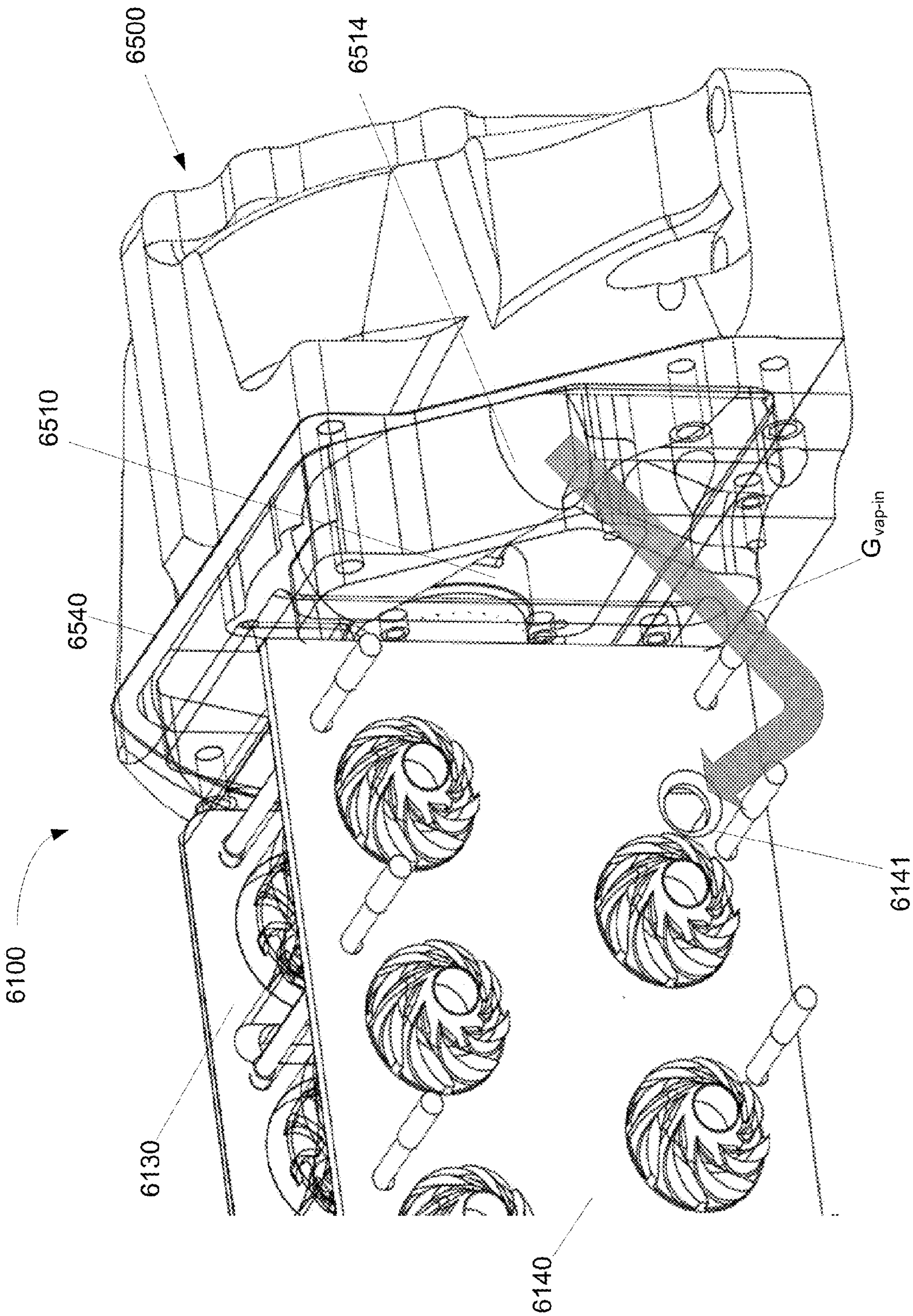
6210
6121
6210
6211
6640
6120
6123
6100

FIG. 15



6000
6142
6121
6142
6110
6142
6122
6546
6142
6140
6142
6142
G_{atom}
6142
6141
6540
G_{in}
6545

FIG. 16



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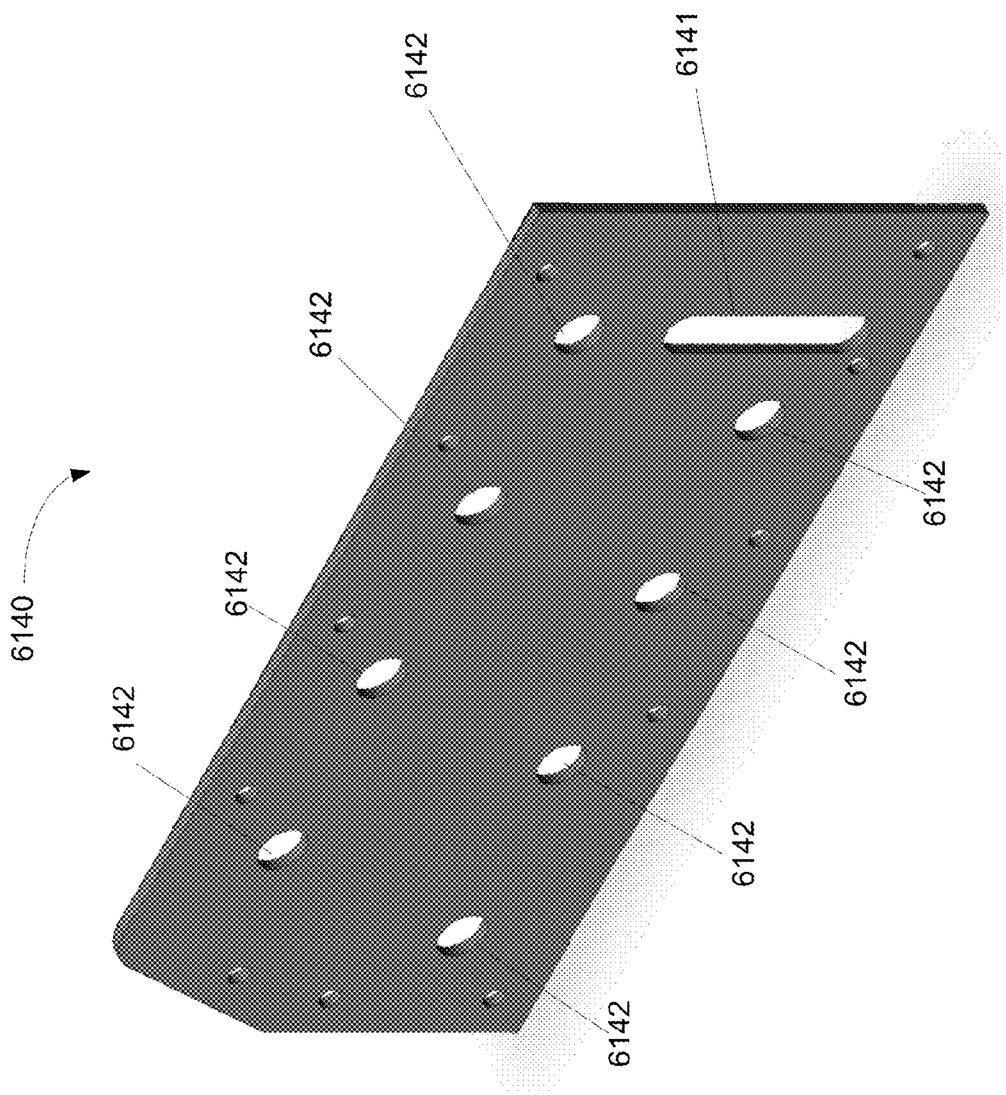


FIG. 18

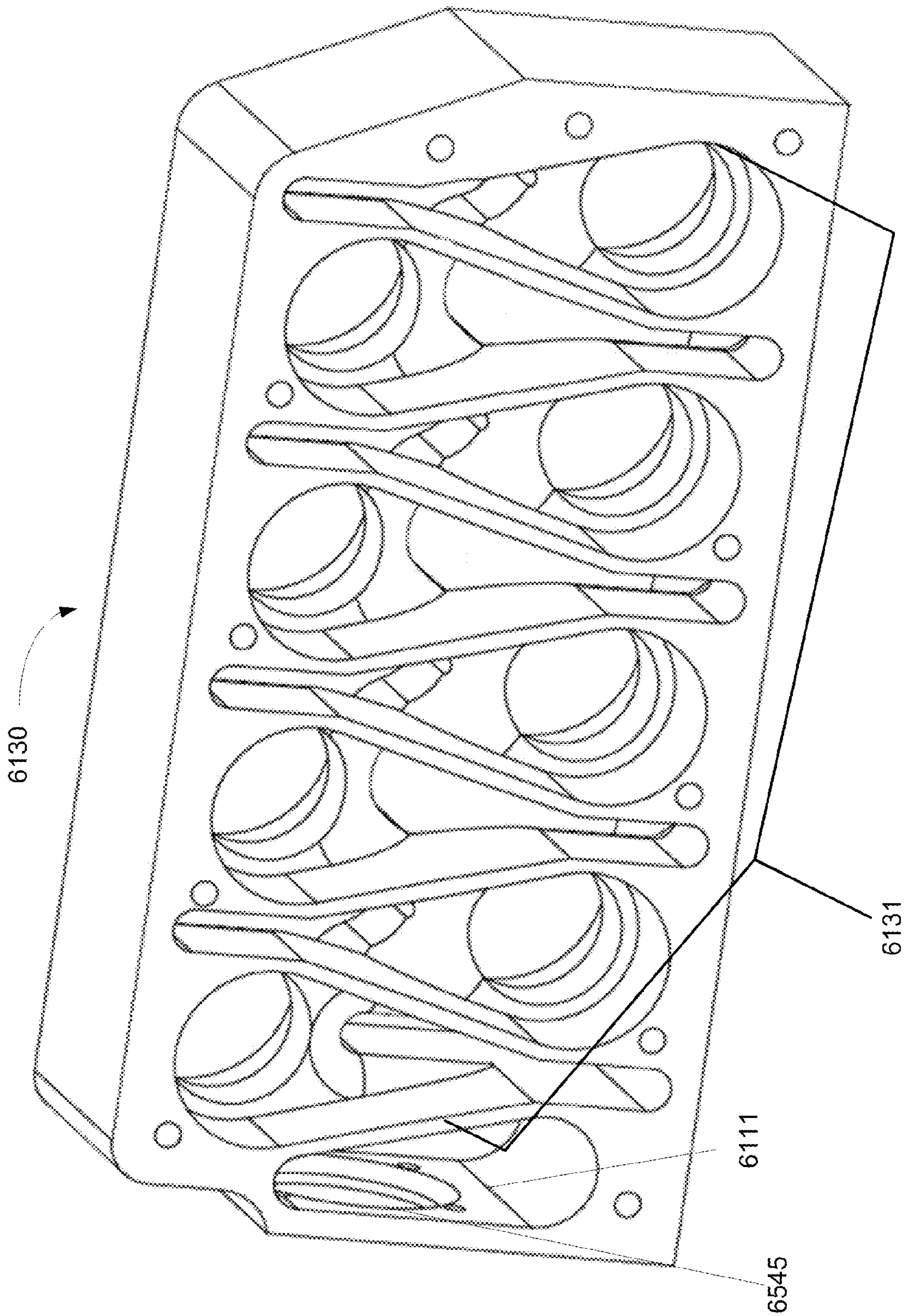
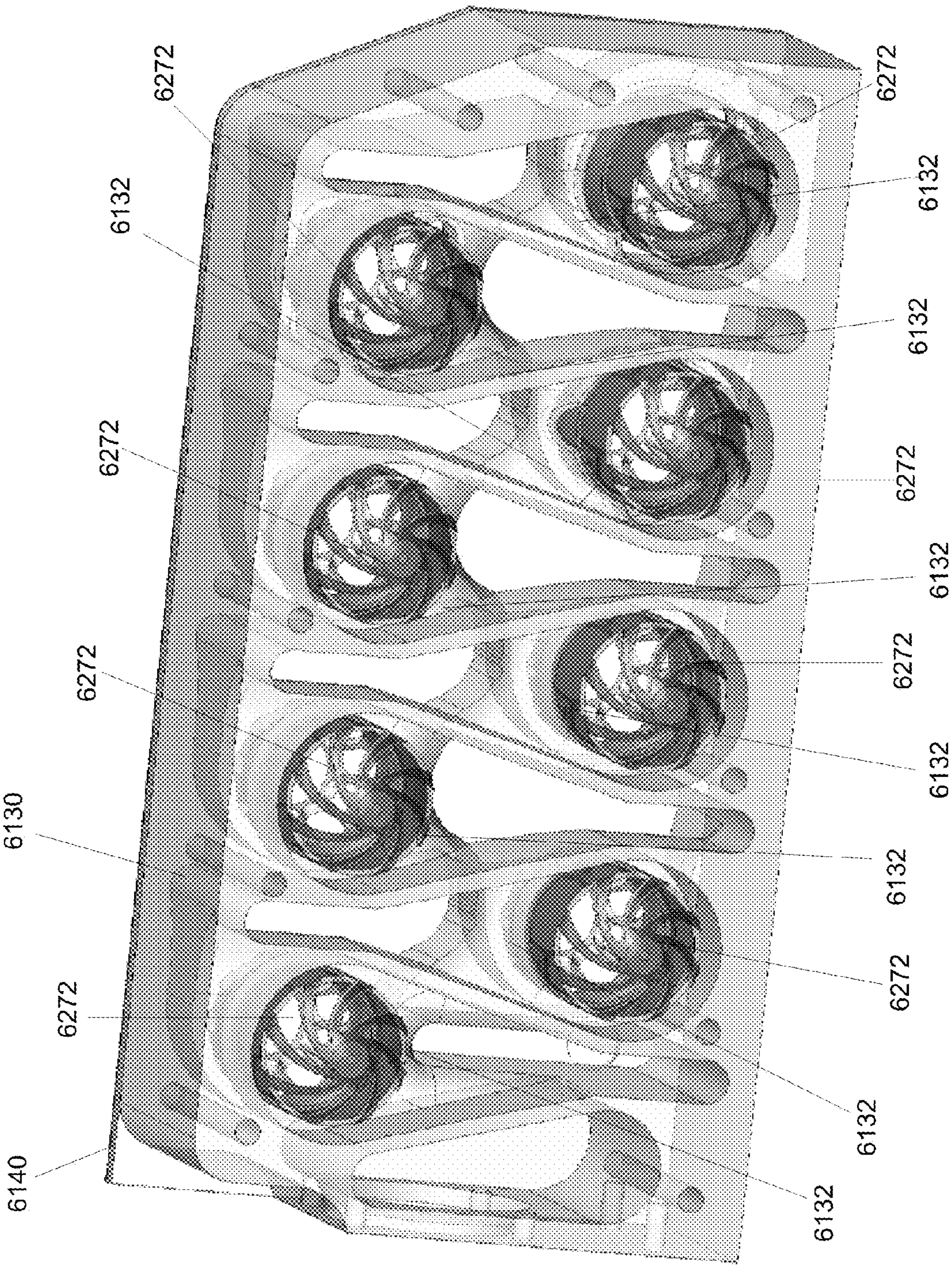


FIG. 19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6132
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6272
6272
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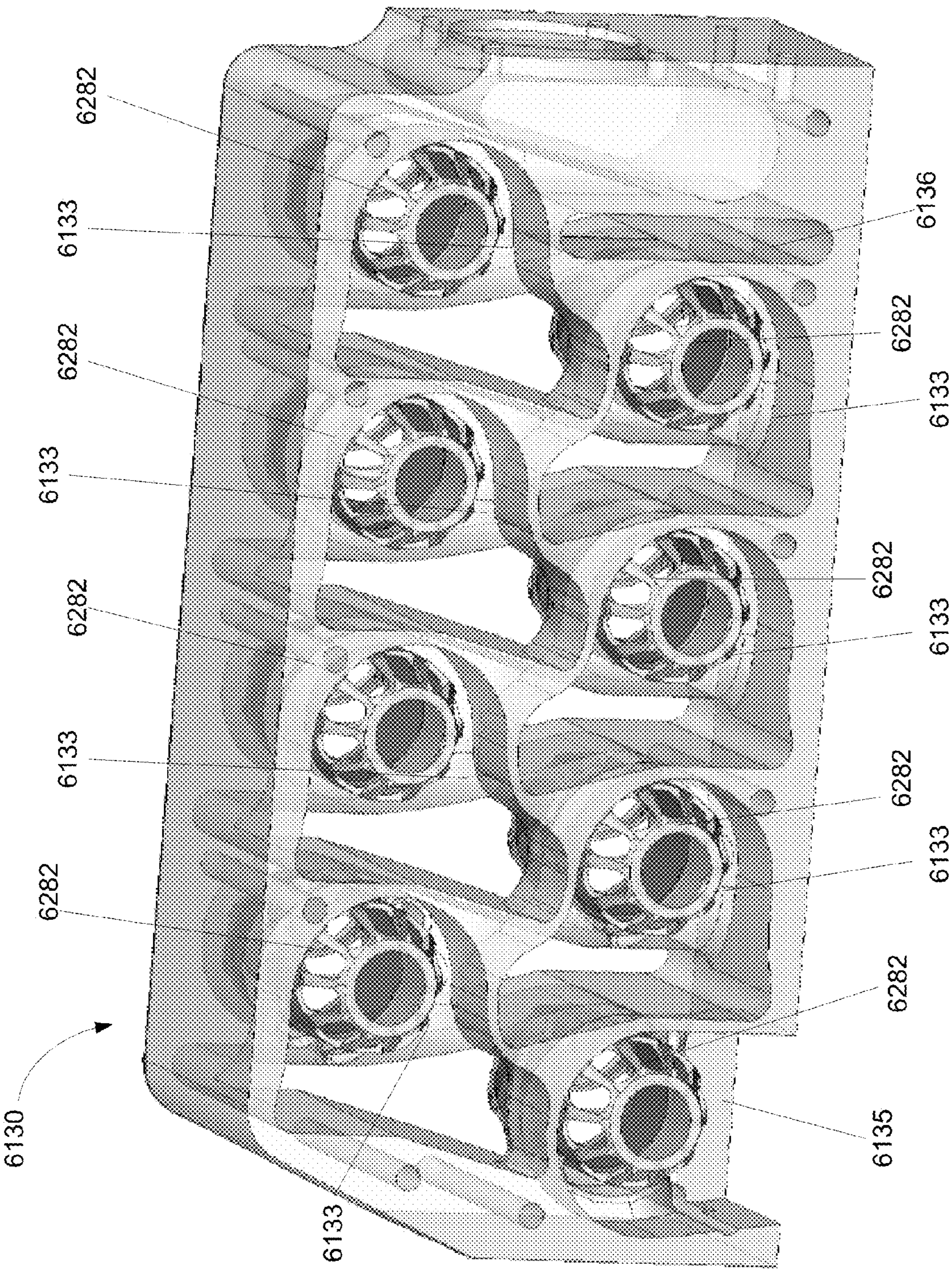
6132
6272
6272
6132
6140
6132

FIG. 20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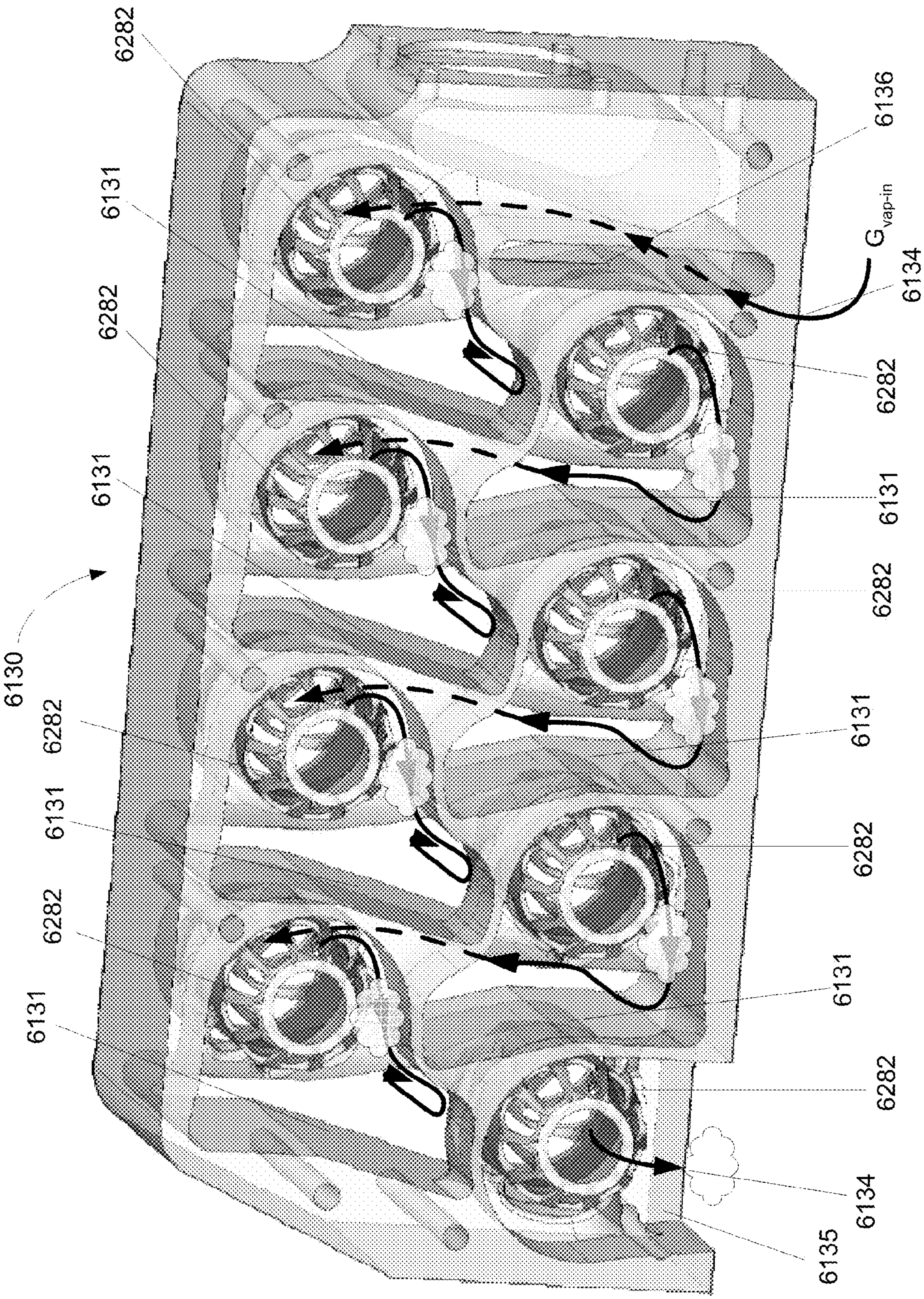
6282
6135

FIG. 21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G_{vap-in}
6134
6282
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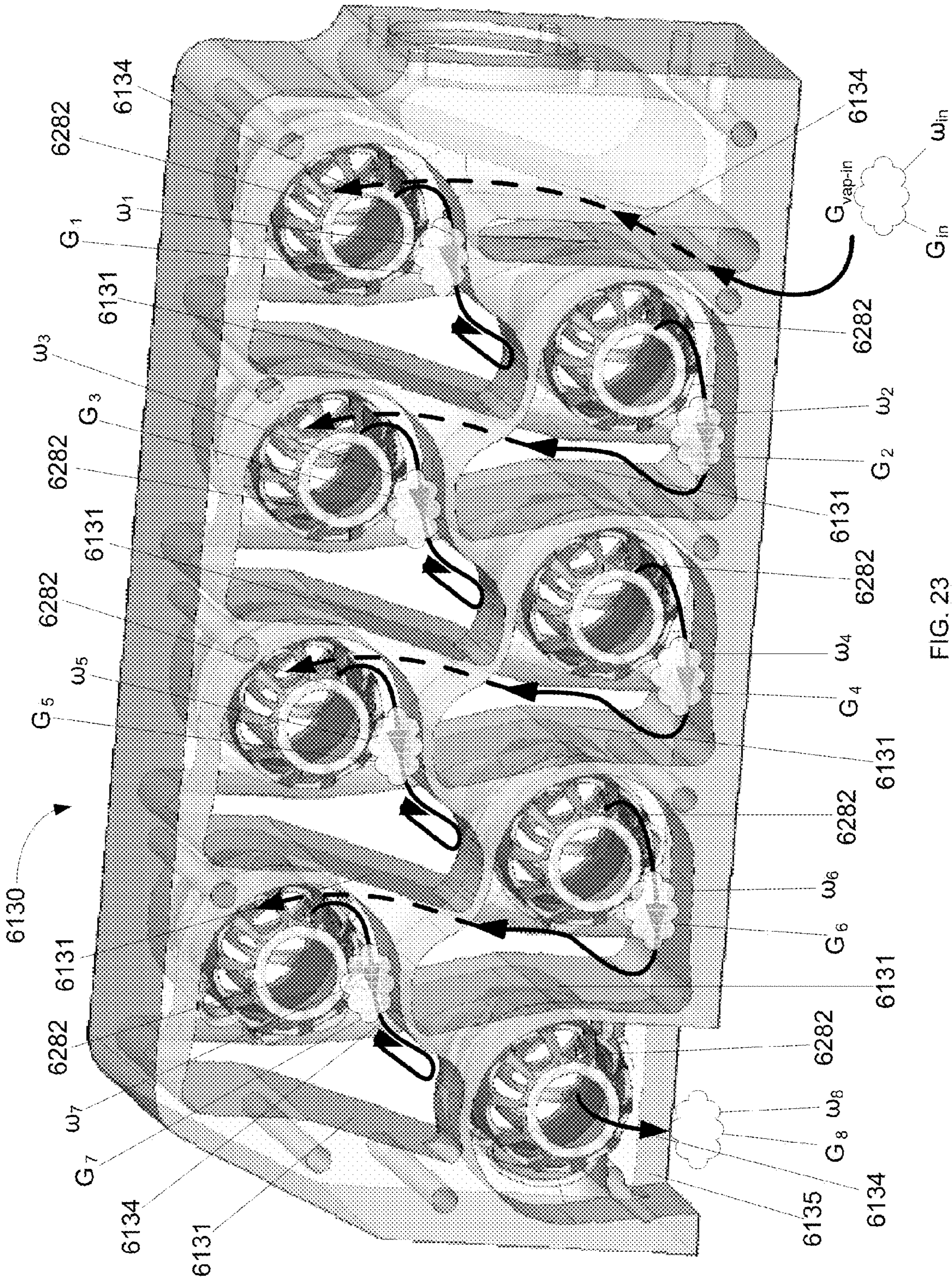
6134
6135

FIG. 22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6134
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ω_1
G_1
6131
ω_3
G_3
6282
6131
6282
ω_5
G_5
6131
6282
ω_7
G_7
6134
6131
$G_{vap\text{-}in}$
ω_{in}
G_{in}
6134
6282
ω_2
G_2
6131
6282
ω_4
G_4
6131
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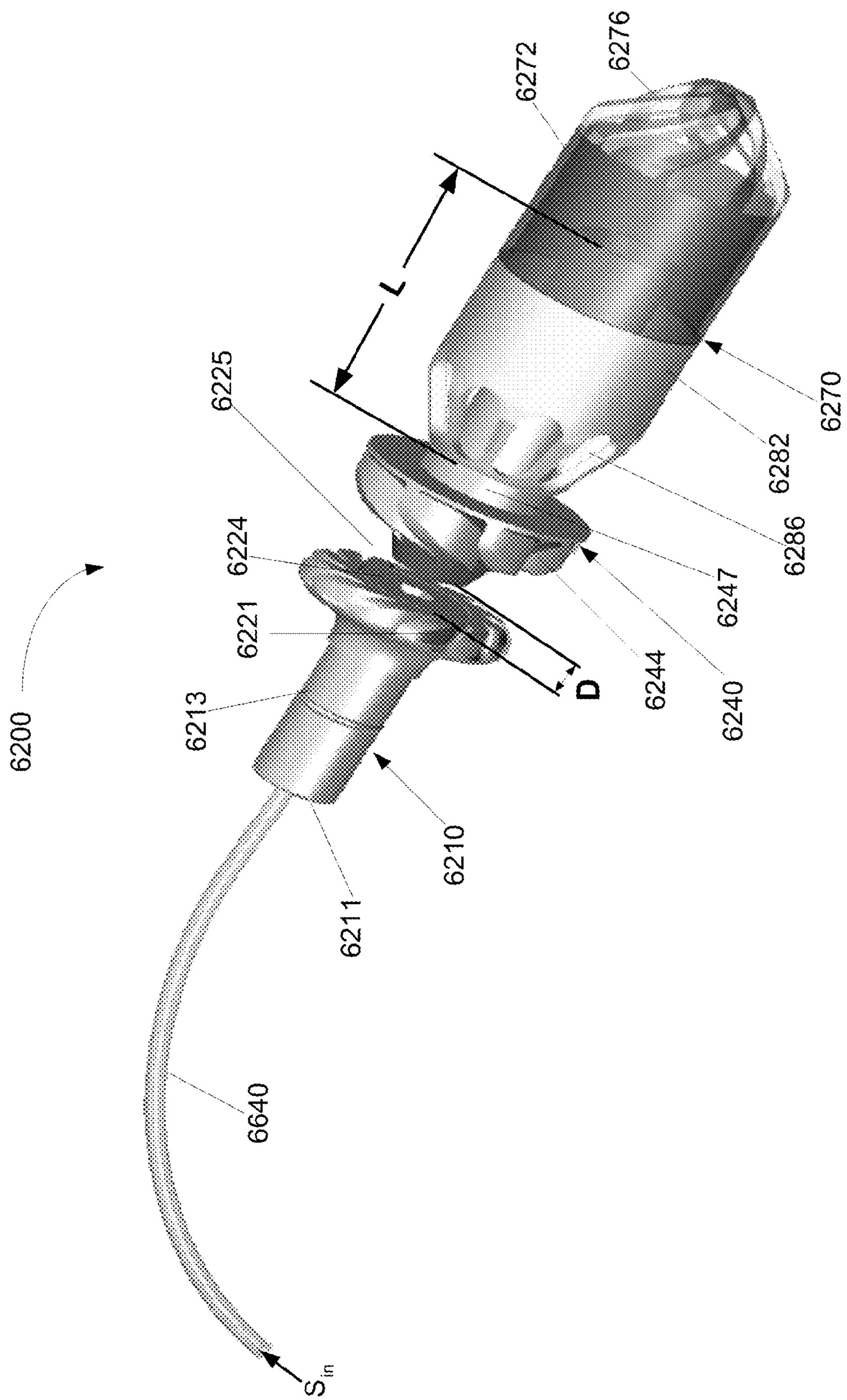
ω_6
G_6
6131
6282
ω_8
G_8
6134
6135

FIG. 23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L
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6224
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D
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6247
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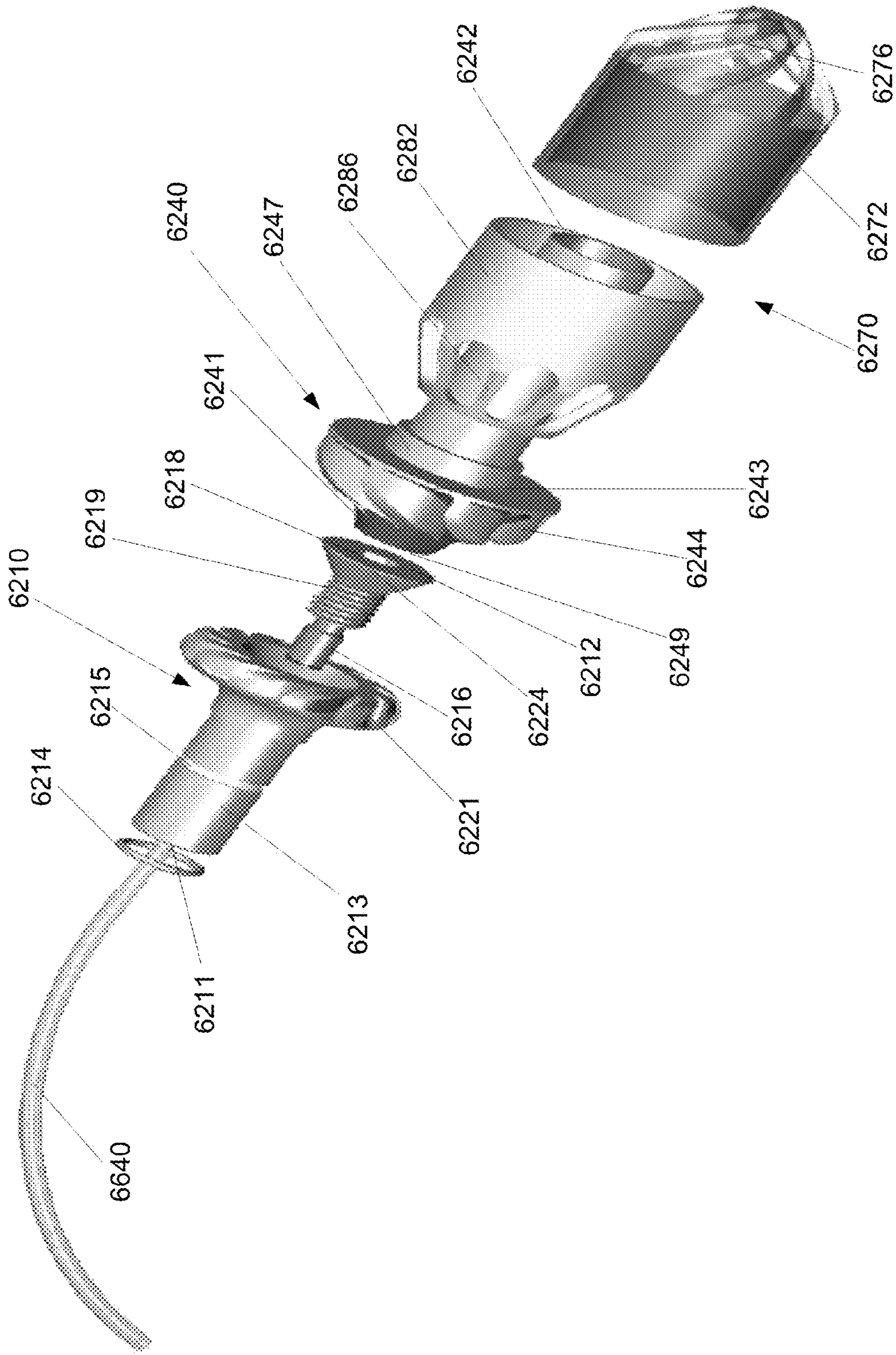
6282
6270
6210
6211
6640
S_{in}

FIG. 24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6221
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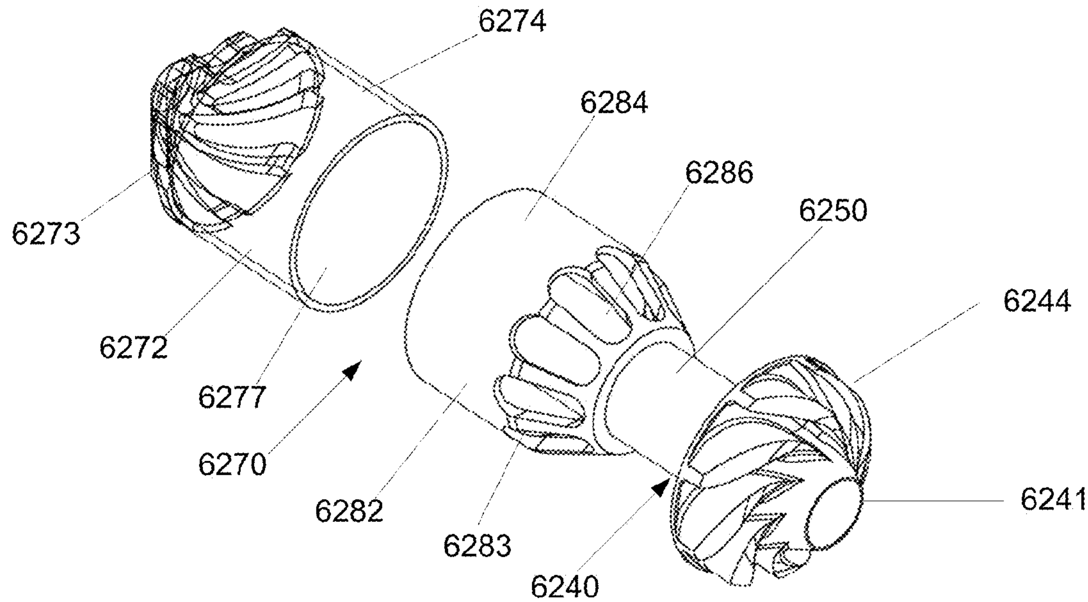
6211
6640

FIG. 25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6240
6241

FIG. 26

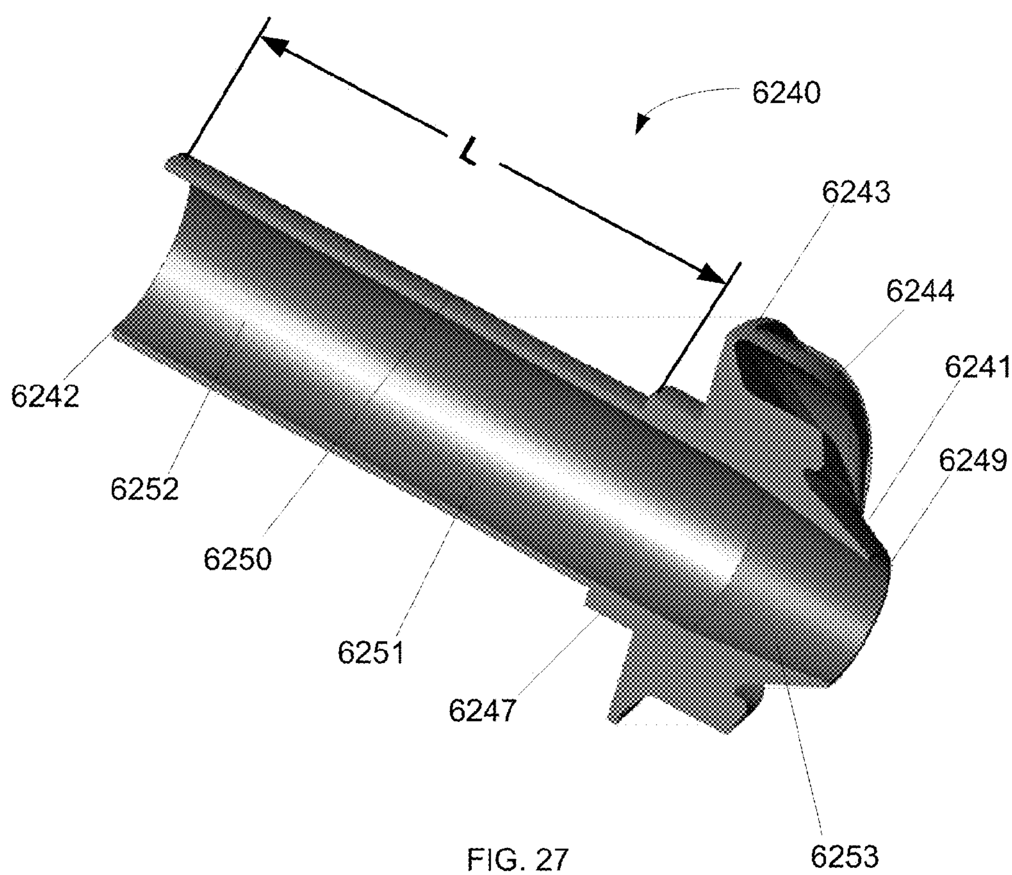
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FIG. 27

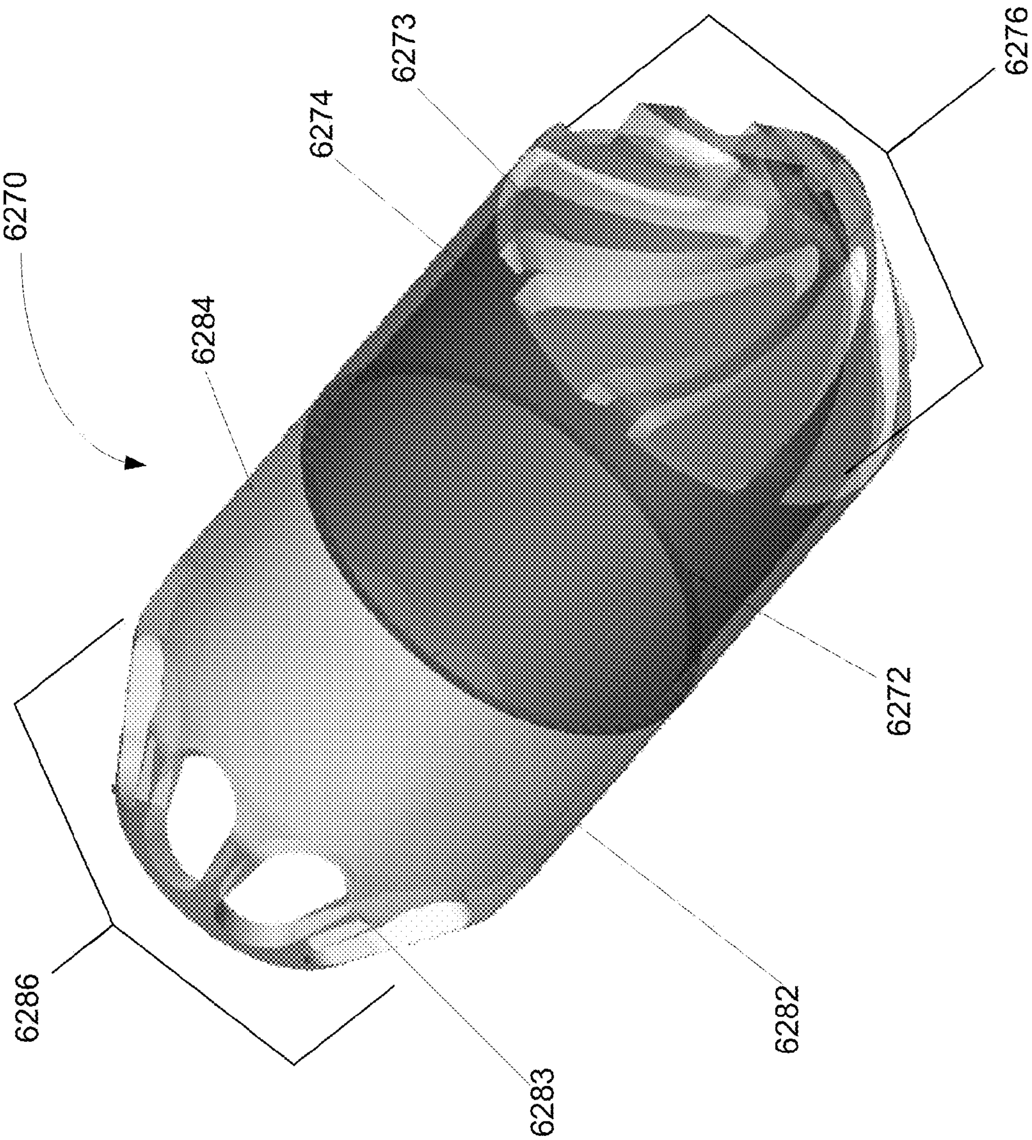
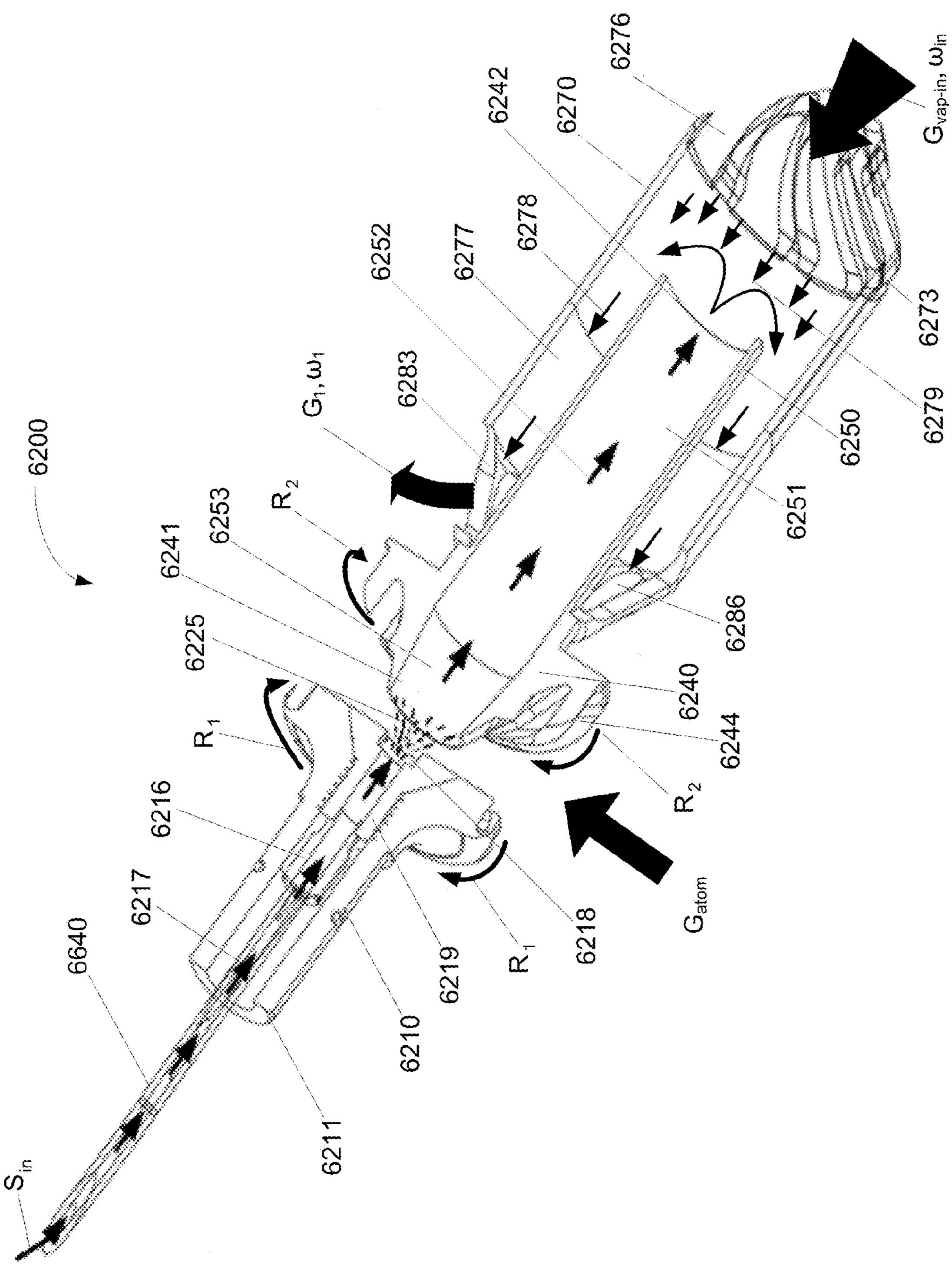


FIG. 28


6200
6276
6242
6270
$G_{vap\text{-}in}, \omega_{in}$
6252
6277
6278
6273
6279
6250
G_1, ω_1
6283
6251
R_2
6253
6241
6286
6225
6240
6244
R_1
R_2
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6217
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6218
G_{atom}
R_1
6219
6210
6211
S_{in}

FIG. 29

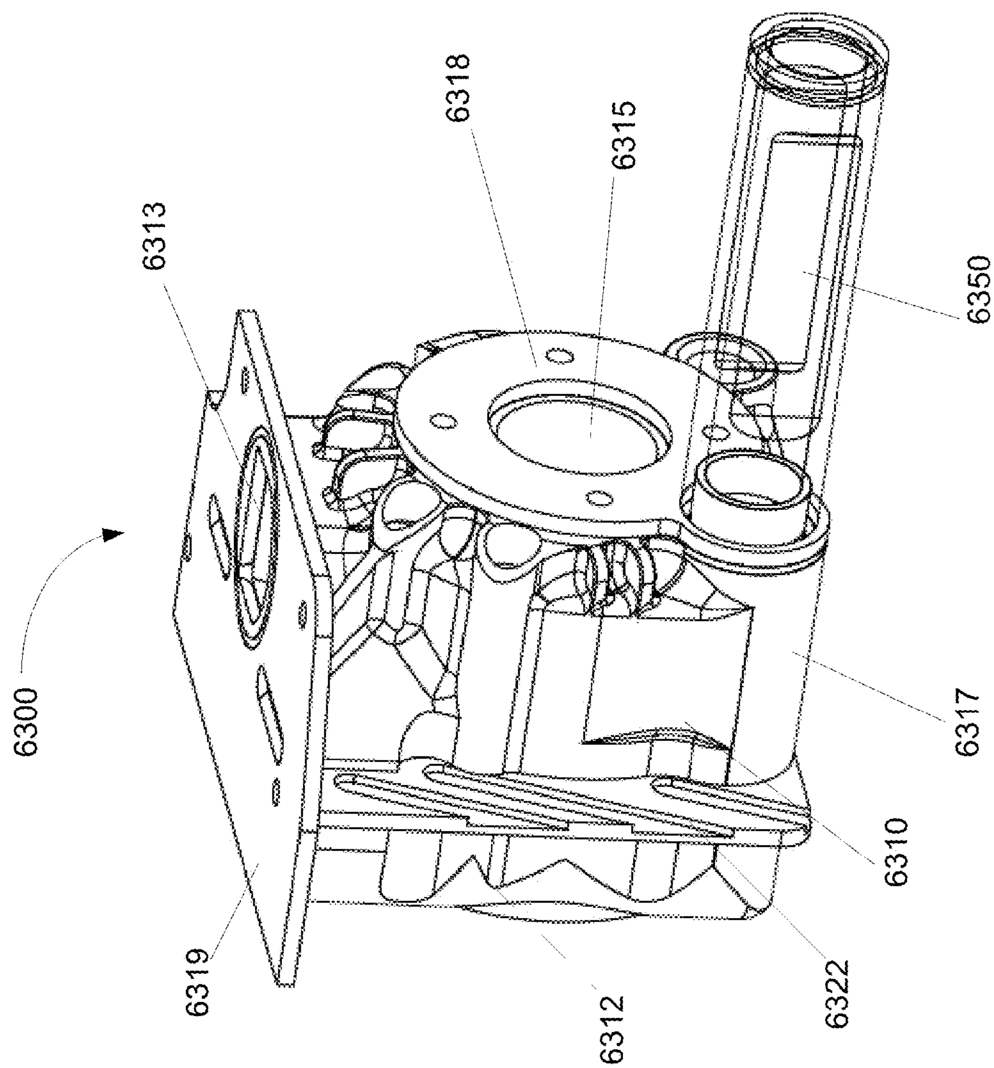
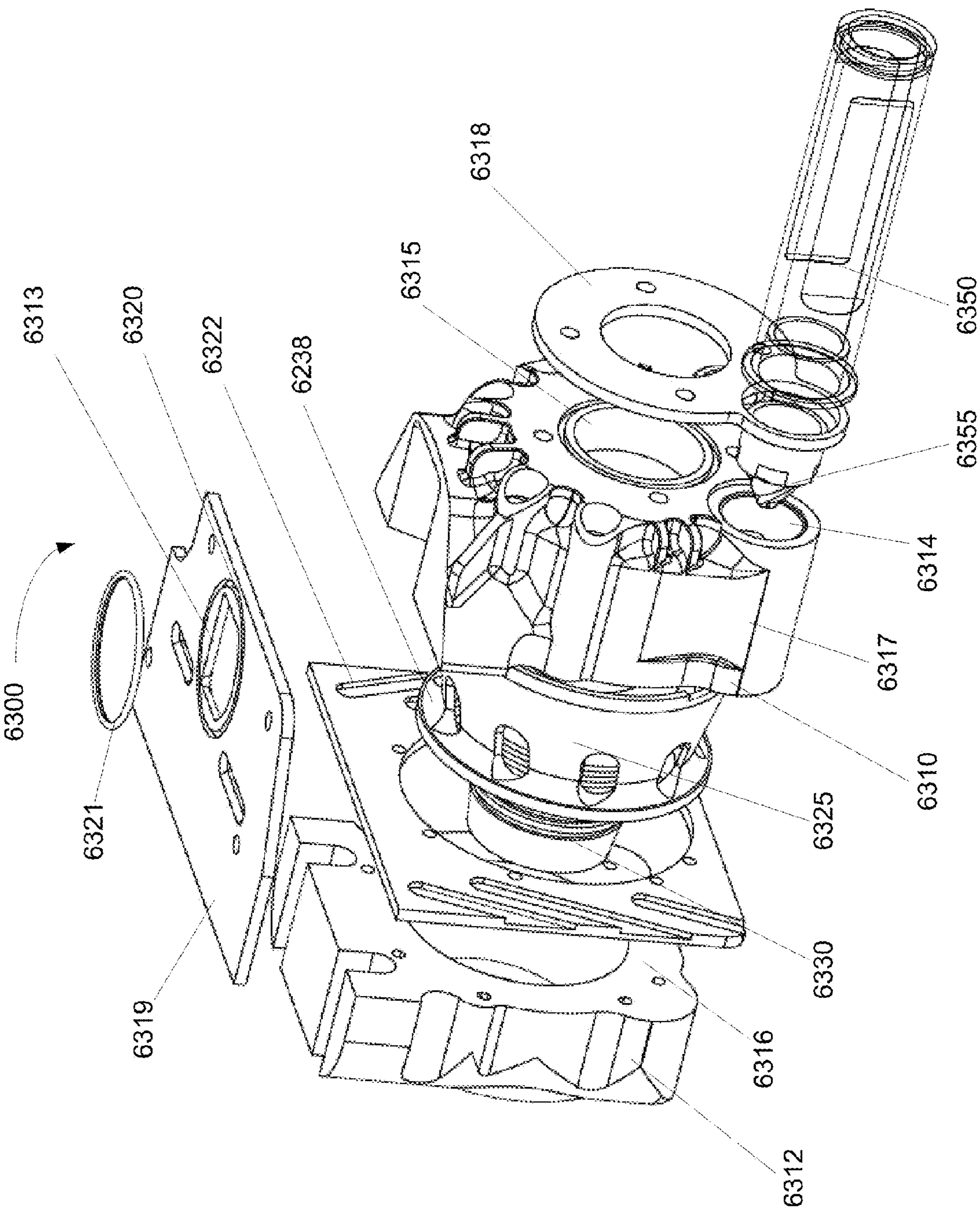


FIG. 30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6321

FIG. 31

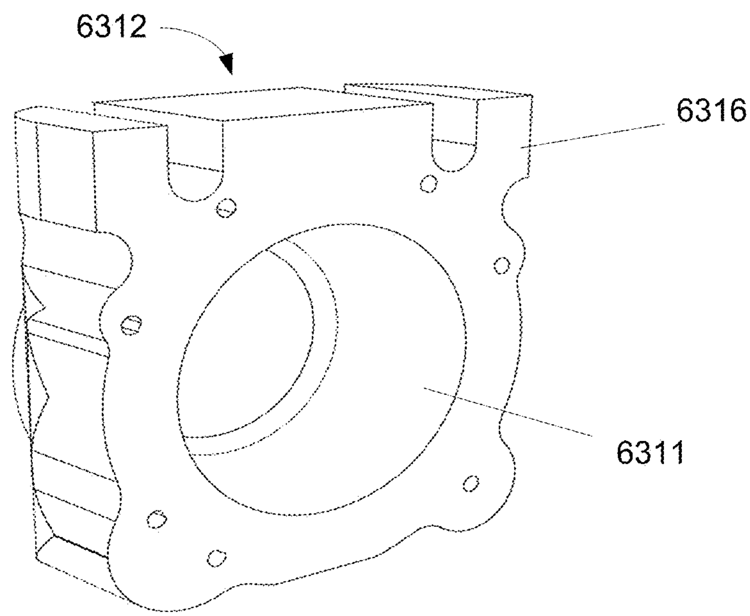


FIG. 32

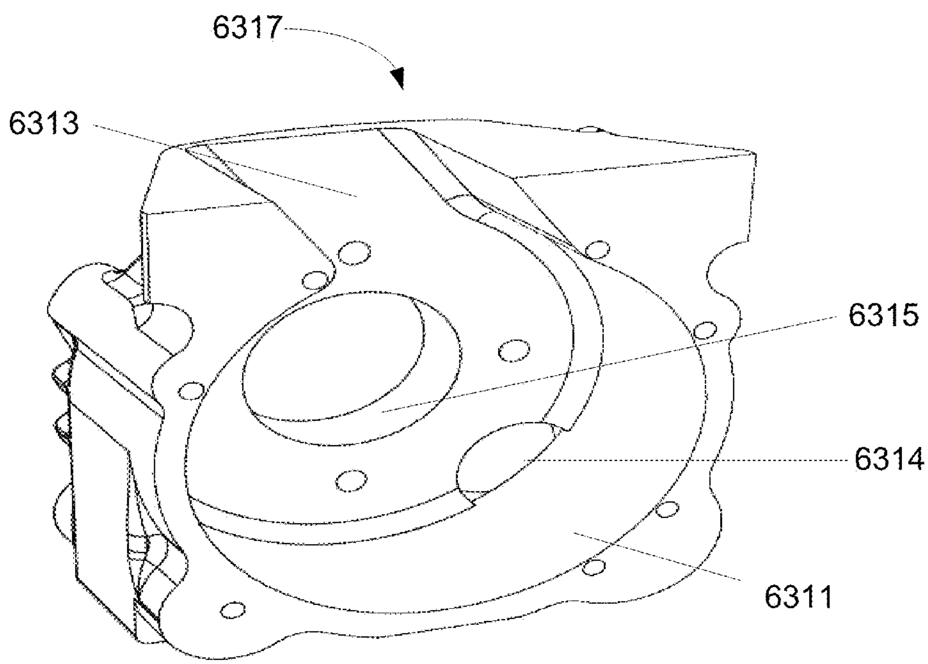


FIG. 33

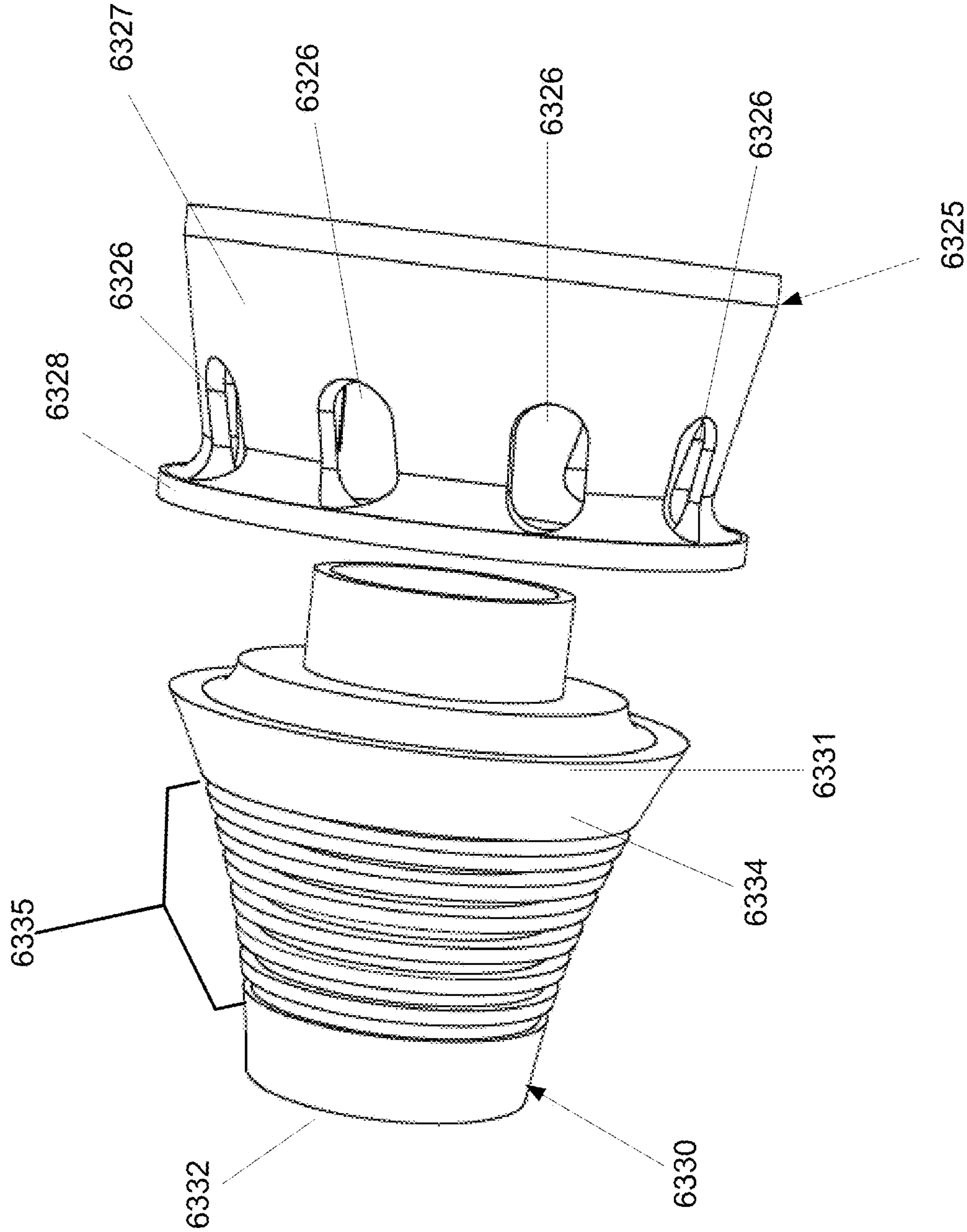
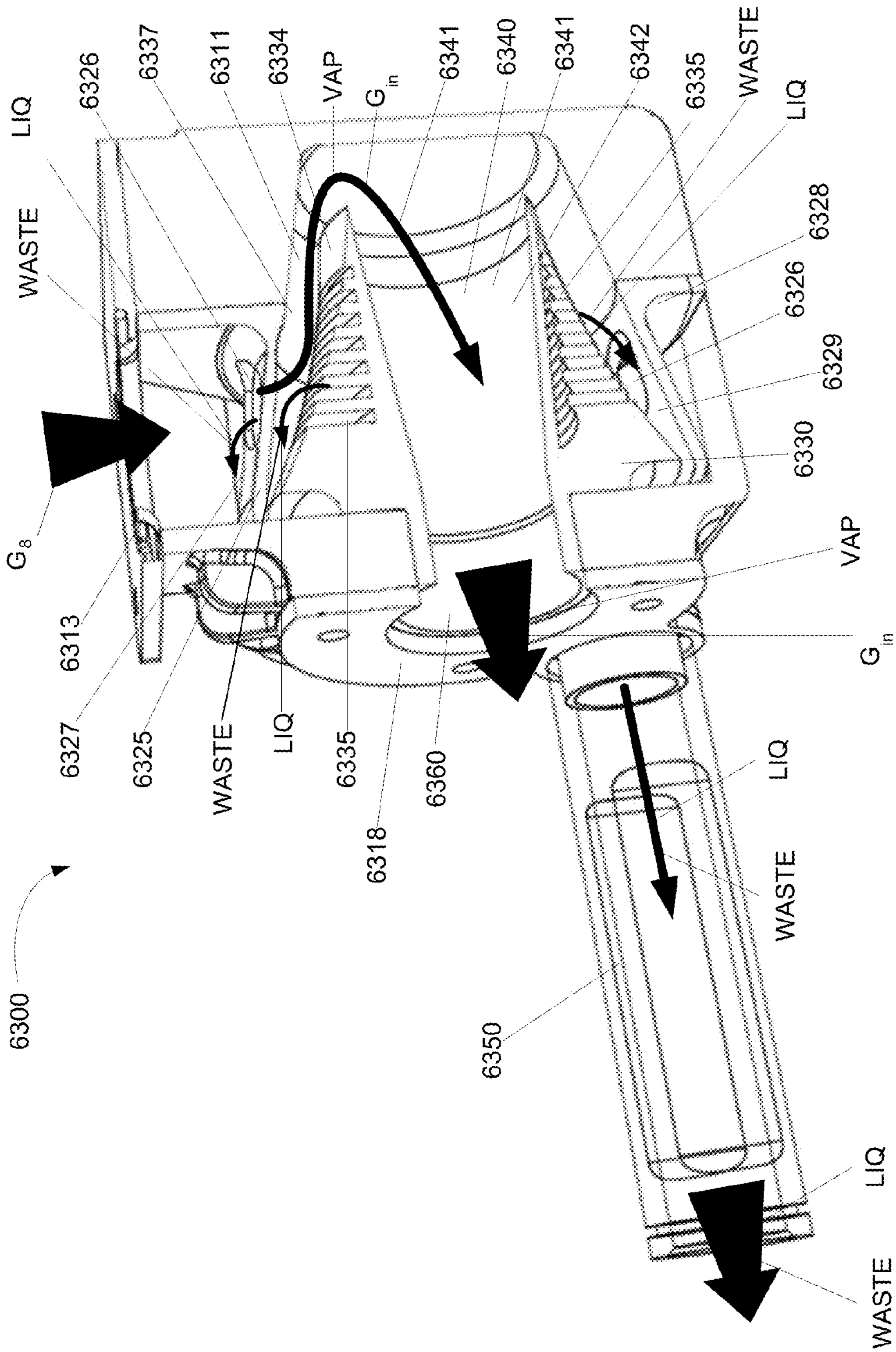


FIG. 34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WASTE
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6311
6334
VAP
G_{in}
6341
6340
6341
6342
6335
WASTE
LIQ
6328
6326
6329
6330
G_8
6313
6327
6325
WASTE
LIQ
6335
6360
6318
VAP
G_{in}
LIQ
WASTE
6350
LIQ
WASTE

FIG. 35

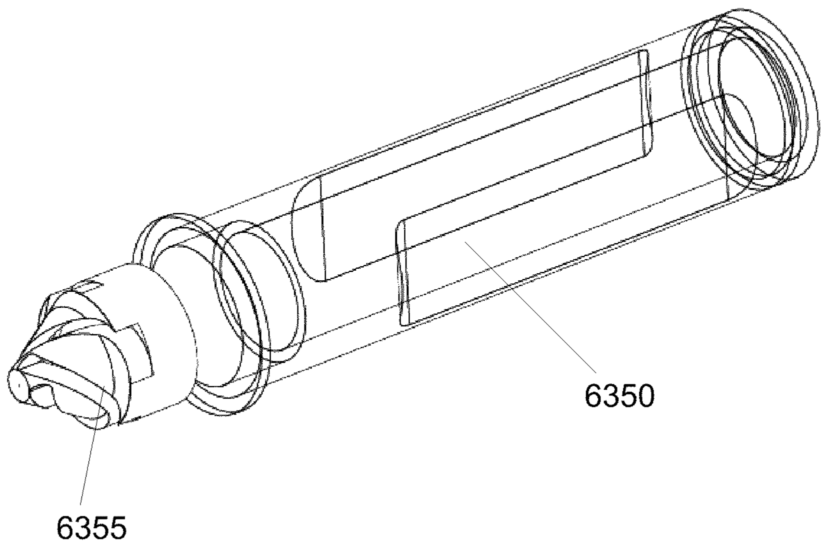


FIG. 36

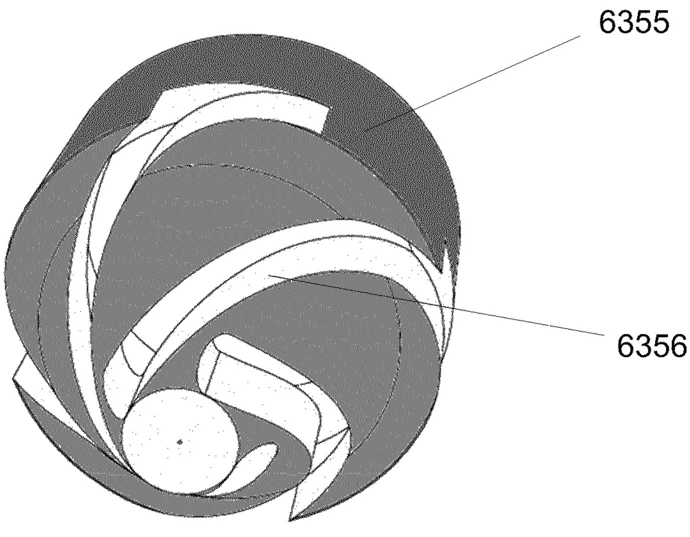


FIG. 37

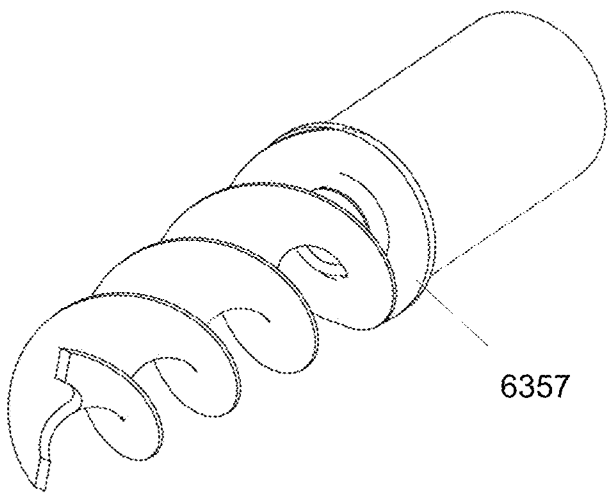


FIG. 38

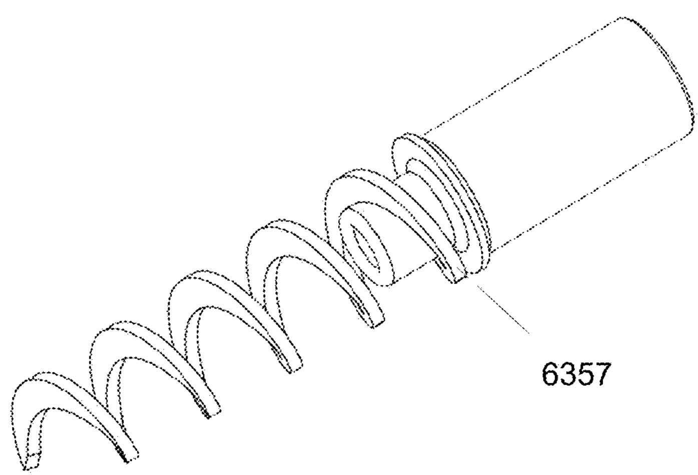
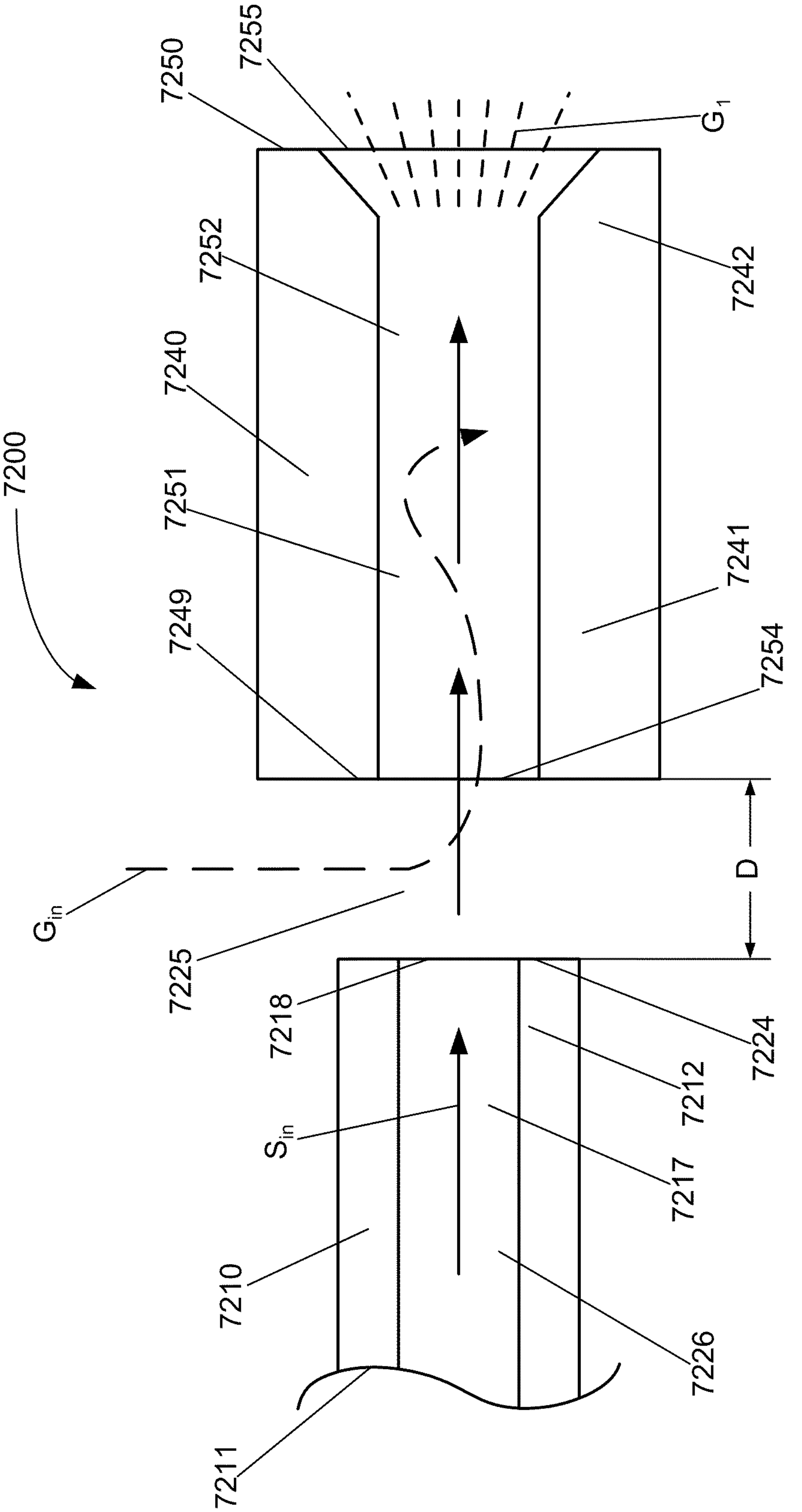
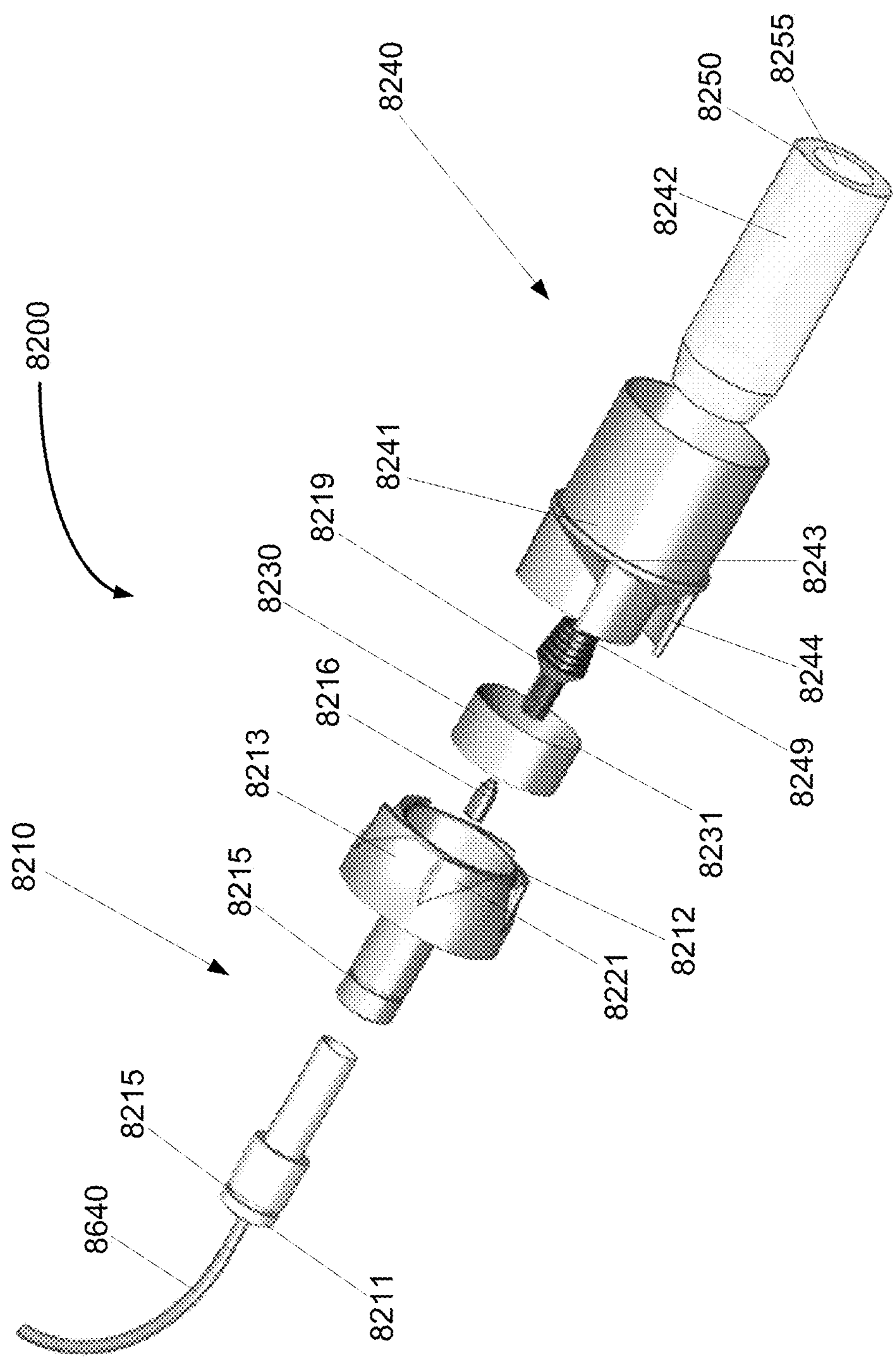


FIG. 39



7200
7255
7250
G1
7252
7242
7240
7251
7241
7249
7254
D
Gin
7225
7218
7224
7212
Sin
7217
7210
7226
7211

FIG. 40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8240
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8255
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8241
8219
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8230
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8249
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8231
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8221
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8640
8211

FIG. 41A

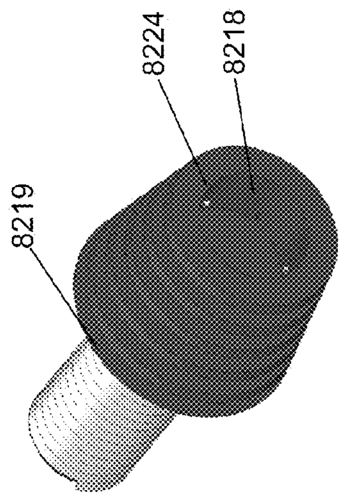


FIG. 41C

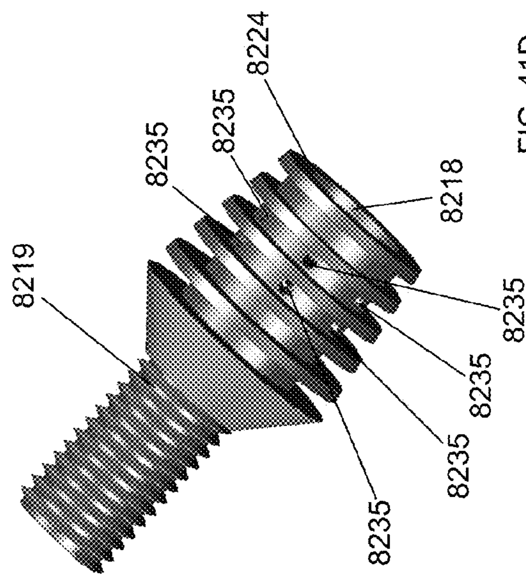


FIG. 41D

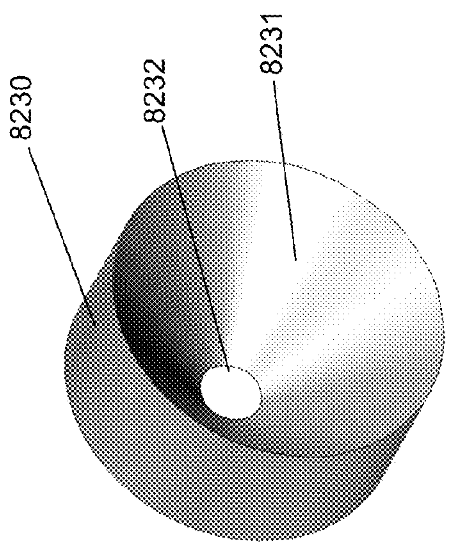


FIG. 41B

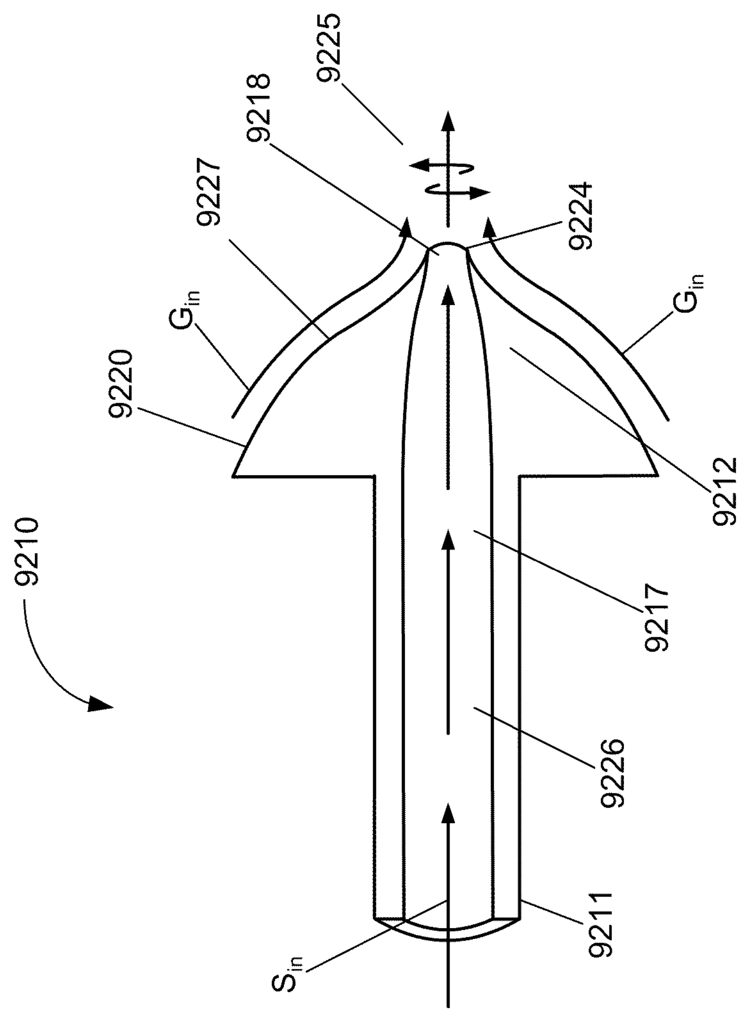


FIG. 42

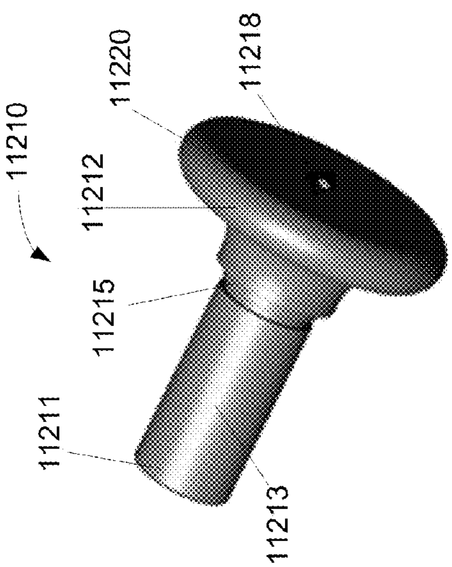


FIG. 44

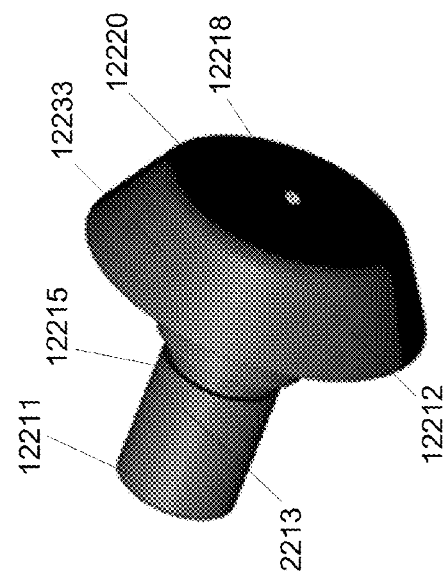


FIG. 45

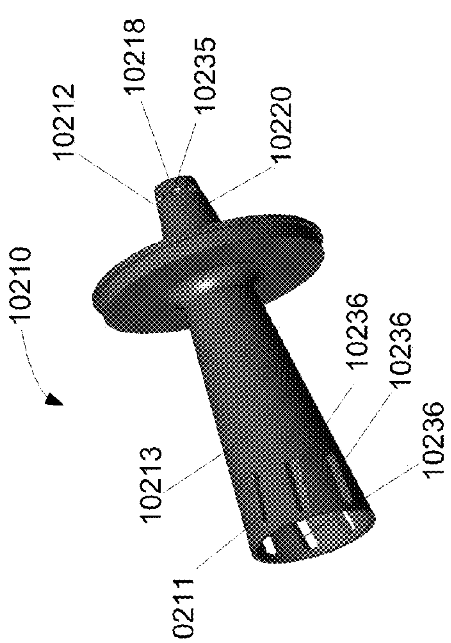


FIG. 43

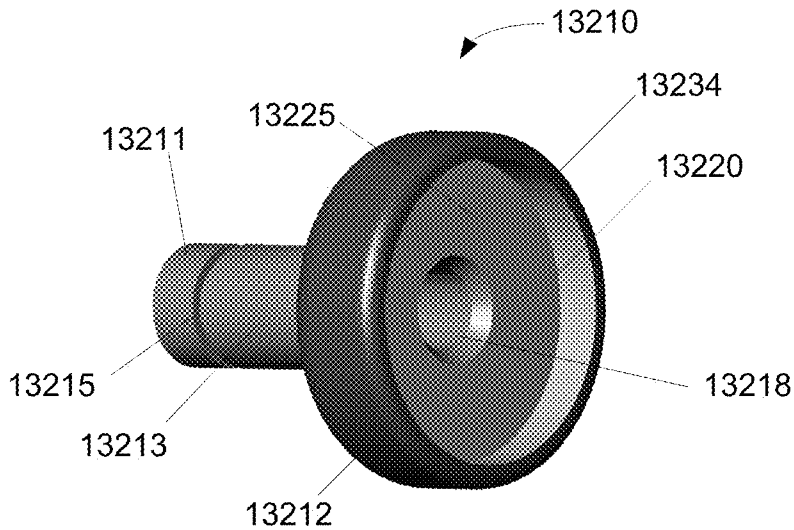

13210
13234
13225
13211
13220
13215
13218
13213
13212

FIG. 46

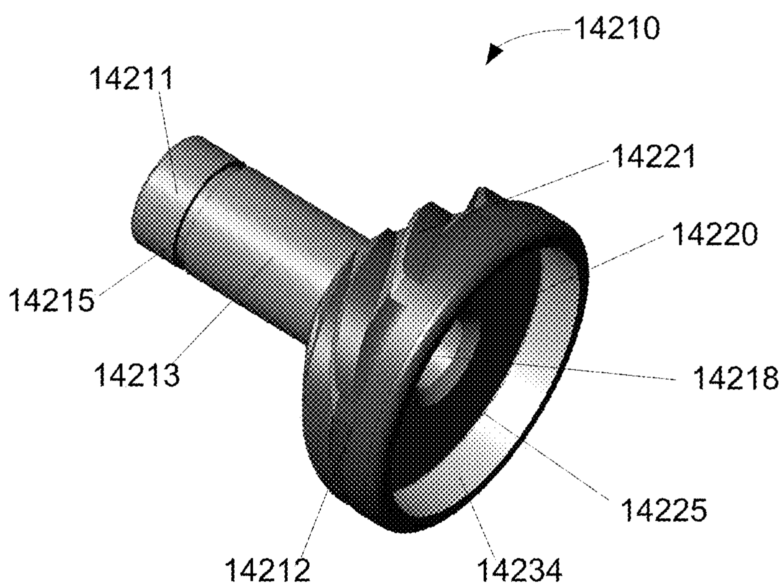
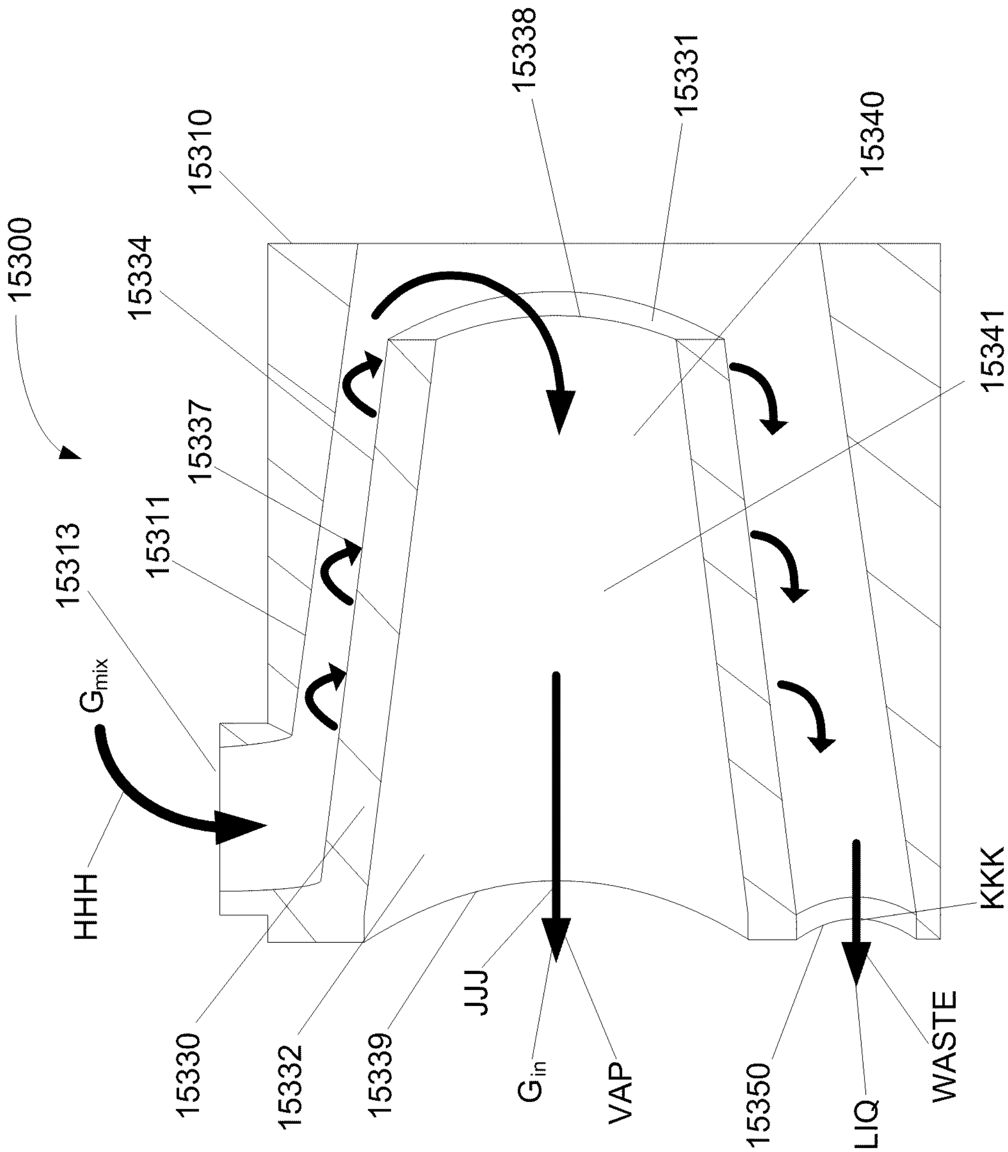
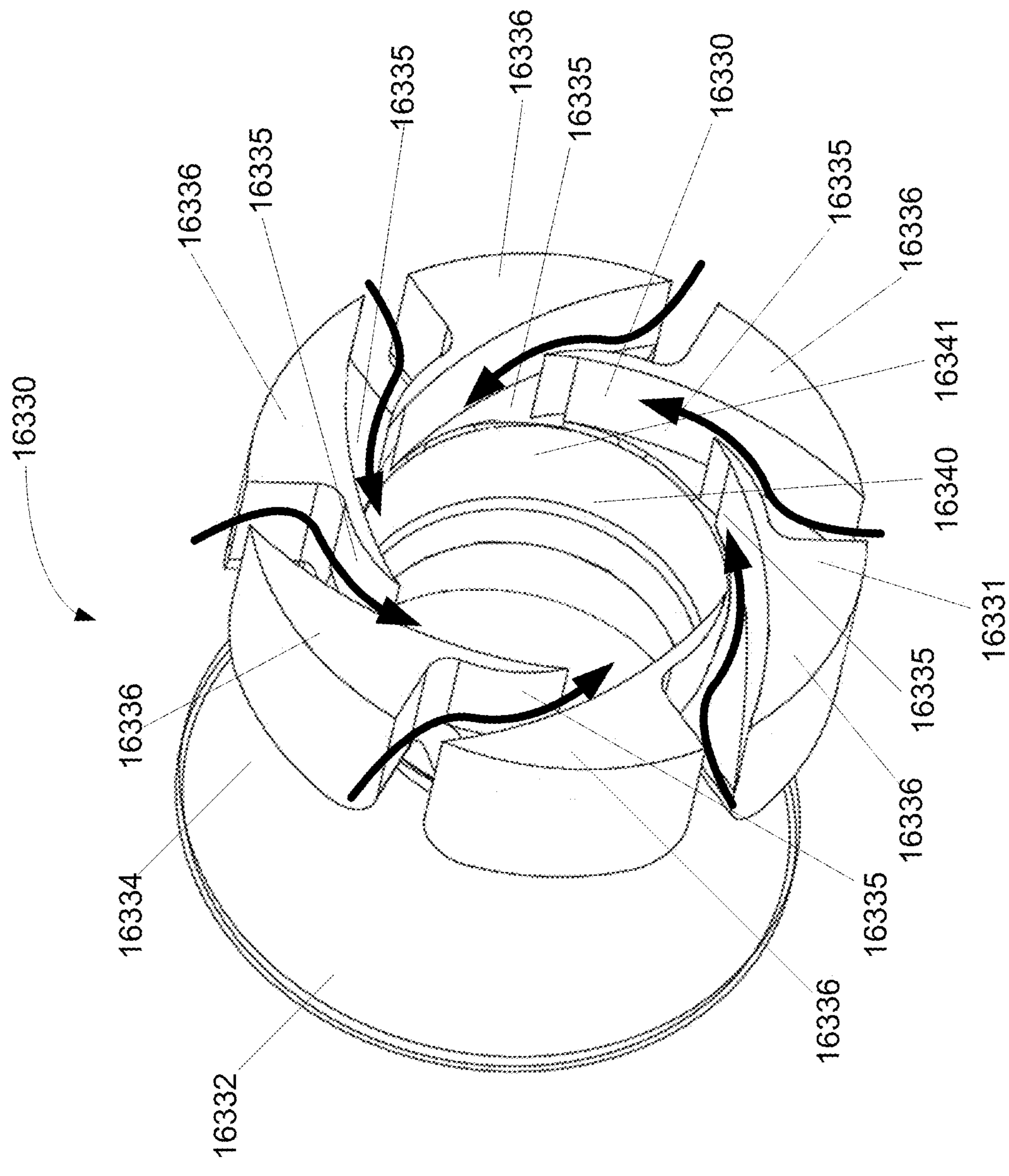

14210
14211
14221
14220
14215
14213
14218
14225
14212
14234

FIG. 47



15300
15310
15334
15338
15331
15340
15341
15337
15311
15313
G_{mix}
HHH
15330
15332
15339
JJJ
G_{in}
VAP
15350
LIQ
WASTE
KKK

FIG. 48


16330
16336
16335
16335
16336
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16336
16341
16340
16331
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16336
16335
16336
16334
16336
16332

FIG. 49

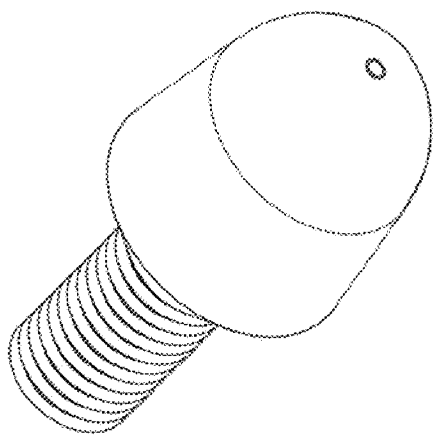

FIG. 50B

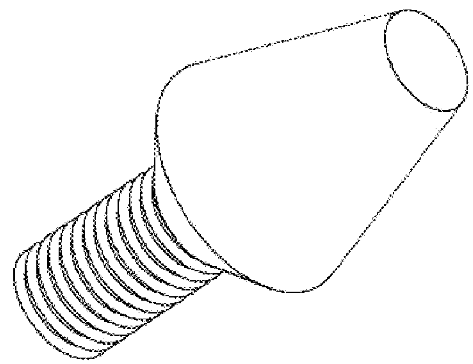

FIG. 50D

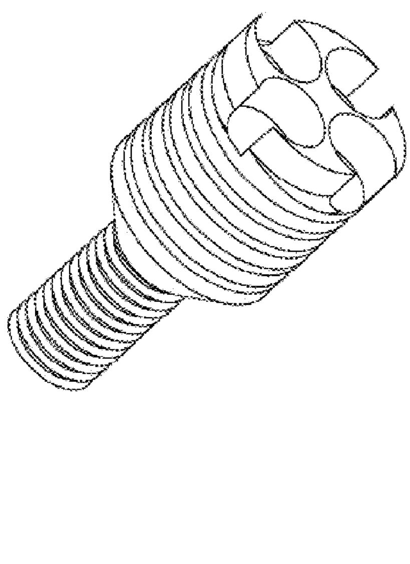

FIG.50A

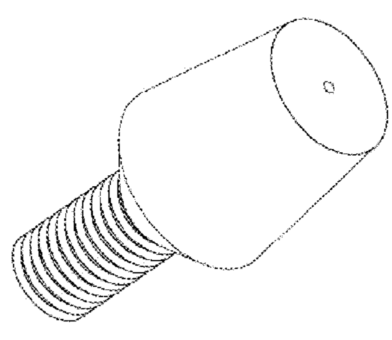

FIG. 50C

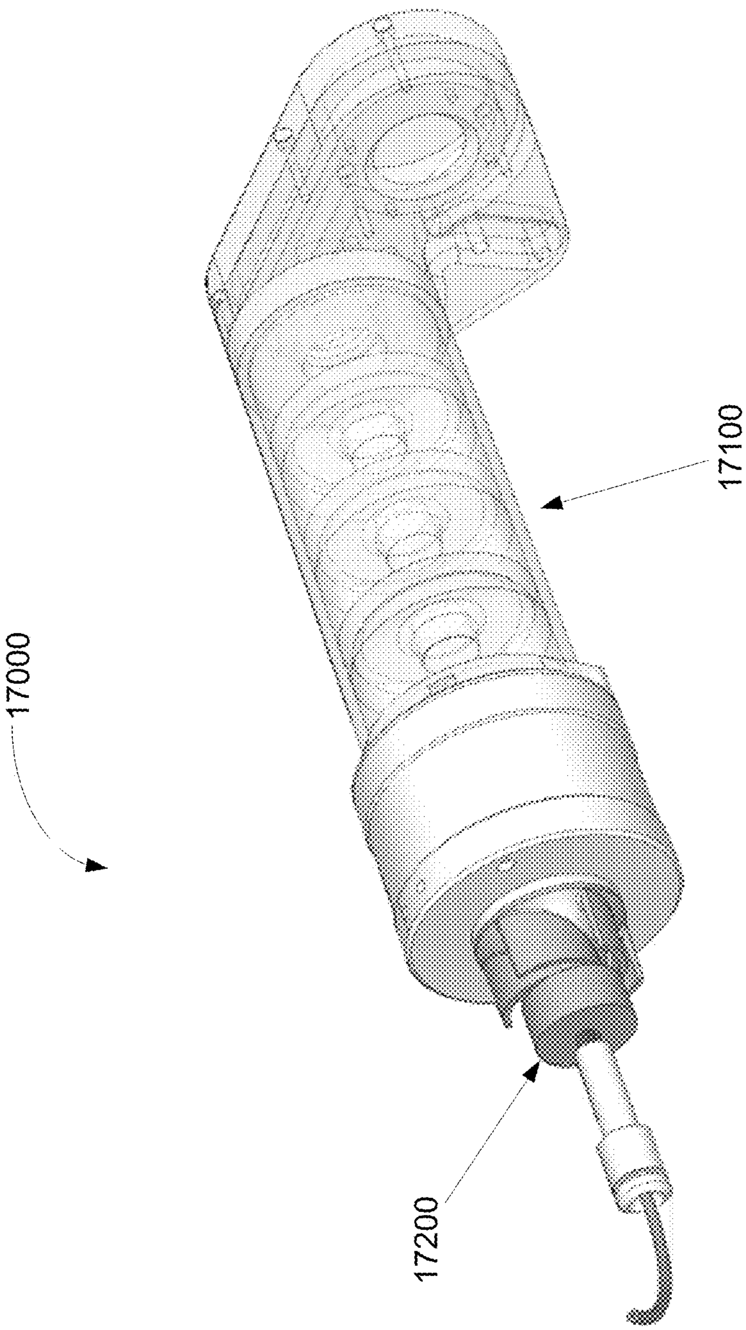

FIG. 51

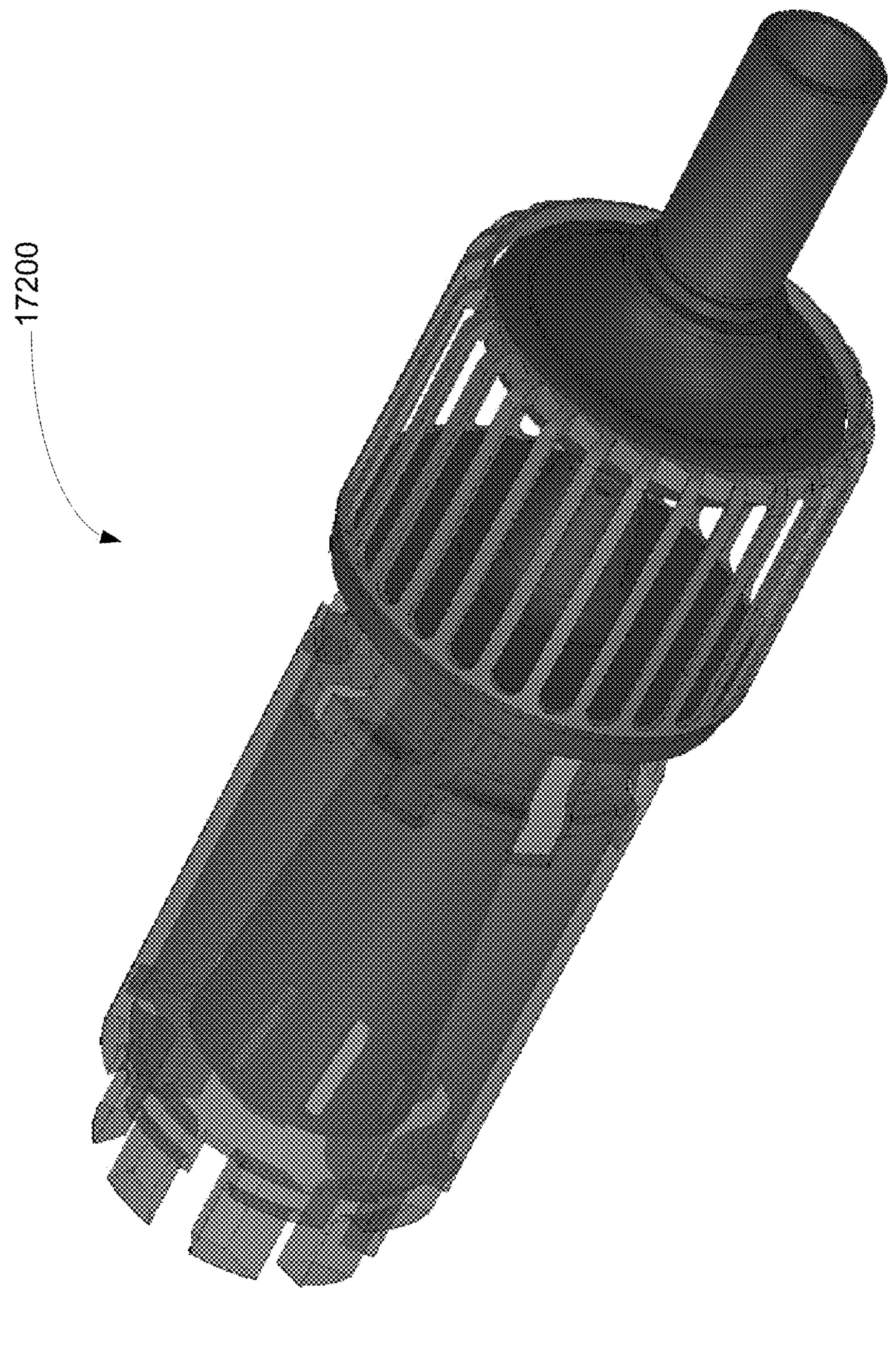

FIG. 52

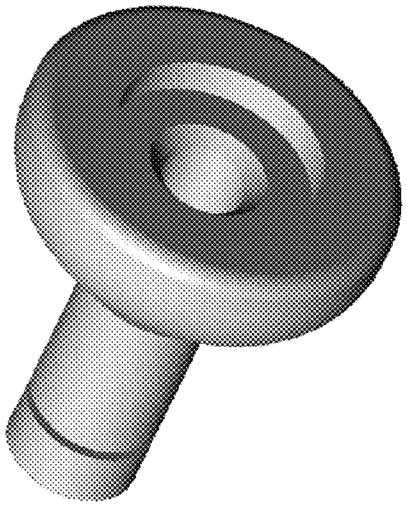
FIG. 53B

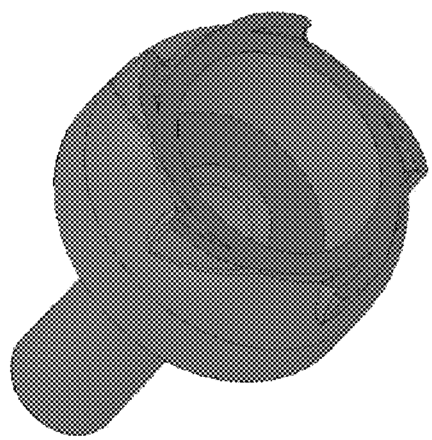
FIG. 53C

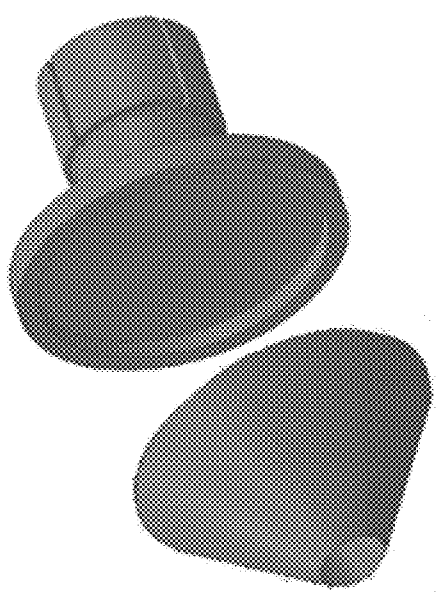
FIG. 53A

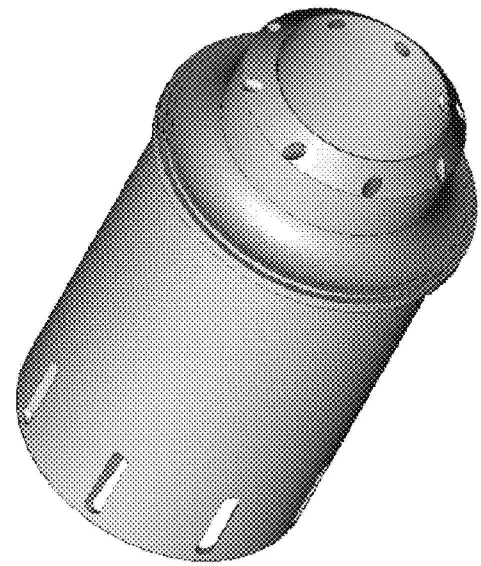

FIG. 54B

FIG. 54C

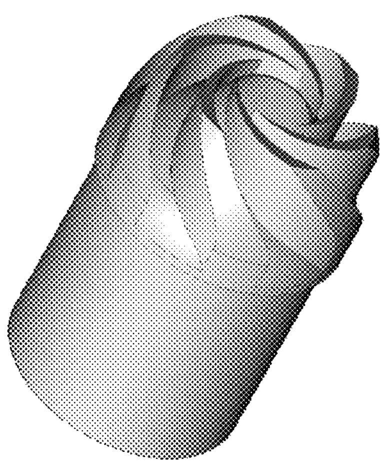

FIG. 54A

SYSTEMS AND METHODS FOR WATER DESALINIZATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 12/636,527, entitled "Compacted Air Flow Rapid Fluid Evaporation System," filed Dec. 11, 2009, which is incorporated herein by reference in its entirety.

BACKGROUND

The embodiments described herein relate to systems and methods for removing a solute from a solution. More particularly, the embodiments described herein relate to systems and methods for water desalinization.

Known water desalinization systems are used to produce potable water from seawater and/or other sources of salt or brackish water. Some known water desalinization systems include filtration systems to remove the solute within the source water, such as, for example, reverse osmosis filtering. Known reverse osmosis desalinization systems produce filtered water by pressurizing the source water to produce the "reverse osmosis" flow (i.e., the flow across a specialized membrane from the area of high solute concentration to the area of low solute concentration). In some known systems, the pressure of the source water can be between 800 and 1000 psi, thus resulting in high-energy consumption during operation. The specialized membranes and/or filters also require periodic replacement and/or maintenance, thereby adding to the cost and complexity of operation. Moreover, some known reverse osmosis desalinization systems have recovery ratios (i.e., the ratio between the flow rate of filtered water to the flow rate of source water) of as low as ten percent.

Other known water desalinization systems produce potable water by distilling the source water. For example, multi-stage flash desalinization systems boil the source water to produce a vapor in multiple stages of operation. The vapor is then condensed to produce the desalinized water. Although the multiple stages are arranged such that the cool inlet water is heated by the vapor as the vapor is condensed, known multi-stage flash desalinization systems consume large amounts of energy to produce the vapor. The boilers of known multi-stage flash desalinization systems also require periodic cleaning and/or maintenance, thereby adding to the cost and complexity of operation.

Yet other known water desalinization systems vaporize the seawater for subsequent condensation and recovery by atomizing the inlet water into ambient air. Such known systems often pressurize the inlet water (for example, to pressures of 100 psi or higher) and/or heat the ambient air, thus resulting in high-energy consumption during operation. Moreover, such known systems often include a long flow path (e.g., similar to a cooling tower flow path) within which the atomized inlet water is evaporated, which increases the size and complexity of the system.

Thus, a need exists for improved systems and methods for water desalinization.

SUMMARY

Systems and methods for water desalinization are described herein. In some embodiments, an apparatus includes a set of atomizers, a housing, and a separator. Each atomizer includes an inlet portion configured to receive an inlet flow of a solution and an outlet portion configured to produce an atomized flow of the solution. The housing has an inlet portion and an outlet portion, and defines a flow path between the inlet portion and the outlet portion. Each atomizer is disposed at least partially within the housing such that the outlet portion of each atomizer is in fluid communication with the flow path. The housing is configured such that a gas flowing within the flow path can be sequentially mixed with the atomized flow of the solution produced by the outlet portion of each atomizer to produce a mixture of the gas and the solution. The separator is configured to be fluidically coupled to the outlet portion of the housing. The separator is configured to receive the mixture of the gas and the solution, and produce a first outlet flow and a second outlet flow. The first outlet flow includes a portion of the gas and a vaporized portion of a solvent from the solution. The second outlet flow includes a liquid portion of the solvent from the solution and a solute from the solution.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is schematic illustrations of a water desalinization system according to an embodiment.

FIG. **2** is a schematic illustration of a processor system according to an embodiment.

FIG. **3** is a schematic illustration of a processor system according to an embodiment.

FIG. **4** is a schematic illustration of a processor system according to an embodiment.

FIG. **5** is a schematic illustration of a processor system according to an embodiment.

FIG. **6** is a right side view of a water desalinization system according to an embodiment.

FIG. **7** is a left side view of the water desalinization system of FIG. **6**.

FIG. **8** is a front perspective view of the water desalinization system of FIG. **6**.

FIG. **9** is a rear perspective view of the water desalinization system of FIG. **6**.

FIG. **10** is a front perspective view of an air processing subsystem according to the embodiment of FIG. **6**.

FIG. **11** is an exploded view of the air processing subsystem of FIG. **10**.

FIG. **12** is a front perspective view of a portion of the water desalinization system of FIG. **6**.

FIG. **13** is rear perspective view of a portion of the water desalinization system of FIG. **6**.

FIG. **14** is an exploded view of a processor system according to the embodiment of FIG. **6**.

FIG. **15** is a perspective view of the processor system of FIG. **14**.

FIG. **16** is a perspective view of a portion of the processor system of FIG. **14**.

FIG. **17** is a perspective view of a portion of the processor system of FIG. **14**.

FIG. **18** is a perspective view of a bulkhead included in the processor system of FIG. **14**.

FIG. **19** is a perspective view of a second portion of a housing according to the processor system of FIG. **14**.

FIG. **20** is a right side of the second portion of the housing and a set of vaporizers according to the processor system of FIG. **14**.

FIG. **21** is a left side of the second portion of the housing and a set of vaporizers according to the processor system of FIG. **14**.

FIG. **22** is a left side view of the second portion of the housing showing a flow path defined by the second portion of the housing according to the processor system of FIG. **14**.

FIG. **23** is a left side view of the second portion of the housing showing the flow path defined by the second portion of the housing according to the processor system of FIG. **14**.

FIG. **24** is a perspective view of an atomizer and a vaporizer of the processor system of FIG. **14**.

FIG. **25** is an exploded view of the atomizer and the vaporizer of FIG. **24**.

FIG. **26** is a perspective view of a nozzle and the vaporizer of the processor system of FIG. **14**.

FIG. **27** is a cross-sectional view of the nozzle of FIG. **26**.

FIG. **28** is a perspective view of the vaporizer of FIG. **26**.

FIG. **29** is a cross-sectional of the atomizer and the vaporizer of FIG. **24**.

FIG. **30** is a perspective view of a separator of the water desalinization system of FIG. **6**.

FIG. **31** is an exploded view of the separator of FIG. **30**.

FIG. **32** is a front perspective view of a rear portion of a housing included in the separator of FIG. **30**.

FIG. **33** is a rear perspective view of a front portion of the housing included in the separator of FIG. **30**.

FIG. **34** is a side view of a first separator member and a second separator member of the separator of FIG. **30**.

FIG. **35** is a cross-sectional view of the separator of FIG. **30**.

FIG. **36** is a perspective view of a waste outlet tube of the separator of FIG. **30**.

FIG. **37** is a perspective view of a waste inlet member included in the waste outlet tube of the separator of FIG. **30**.

FIGS. **38** and **39** are perspective views of an auger that can be included in the waste outlet tube of FIG. **36**.

FIG. **40** is a schematic illustration of a cross-section of an atomizer, according to an embodiment.

FIG. **41**A is a perspective view of an atomizer according to an embodiment.

FIG. **41**B is a zoomed perspective view of a mixing insert included in the atomizer of FIG. **41**A.

FIG. **41**C is a first zoomed perspective view of an injector insert included in the atomizer of FIG. **41**A.

FIG. **41**D is a second zoomed perspective view of the injector insert included in the atomizer of FIG. **41**A.

FIG. **42** is a schematic illustration of a cross-section of an injector, according to an embodiment.

FIG. **43** is a perspective view of a portion of an atomizer assembly according to an embodiment.

FIG. **44** is a perspective view of an injector according to an embodiment.

FIG. **45** is a perspective view of an injector according to an embodiment.

FIG. **46** is a perspective view of an injector according to an embodiment.

FIG. **47** is a perspective view of an injector according to an embodiment.

FIG. **48** is a schematic illustration of a cross-section of a separator, according to an embodiment.

FIG. **49** is a rear perspective view of a separator member, according to an embodiment.

FIG. **50**A is a perspective view of an injector insert, according to an embodiment.

FIG. **50**B is a perspective view of an injector insert, according to an embodiment.

FIG. **50**C is a perspective view of an injector insert, according to an embodiment.

FIG. **50**D is a perspective view of an injector insert, according to an embodiment.

FIG. **51** is a perspective view of a portion of a water desalinization unit, according to an embodiment.

FIG. **52** is a perspective view of an atomizer, according to an embodiment.

FIG. **53**A is an exploded perspective view of an injector, according to an embodiment.

FIG. **53**B is a perspective view of an injector, according to an embodiment.

FIG. **53**C is a perspective view of an injector, according to an embodiment.

FIG. **54**A is a perspective view of a nozzle, according to an embodiment.

FIG. **54**B is a perspective view of a nozzle, according to an embodiment.

FIG. **54**C is a perspective view of a nozzle, according to an embodiment.

DETAILED DESCRIPTION

Systems and methods for water desalinization are described herein. In some embodiments, an apparatus includes a set of atomizers, a housing and a separator. Each atomizer includes an inlet portion configured to receive an inlet flow of a solution and an outlet portion configured to produce an atomized flow of the solution. The housing has an inlet portion and an outlet portion, and defines a flow path between the inlet portion and the outlet portion. Each atomizer is disposed at least partially within the housing such that the outlet portion of each atomizer is in fluid communication with the flow path. The housing is configured such that a gas flowing within the flow path can be sequentially mixed with the atomized flow of the solution produced by the outlet portion of each atomizer to produce a mixture of the gas and the solution. The separator is configured to be fluidically coupled to the outlet portion of the housing. The separator is configured to receive the mixture of the gas and the solution, and produce a first outlet flow and a second outlet flow. The first outlet flow includes a portion of the gas and a vaporized portion of a solvent from the solution. The second outlet flow includes a liquid portion of the solvent from the solution and a solute from the solution.

In some embodiments, an apparatus includes a set of atomizers, a housing and a separator. Each atomizer includes an inlet portion configured to receive an inlet flow of a solution and an outlet portion configured to produce an atomized flow of the solution. The housing has an inlet portion and an outlet portion, and defines a flow path between the inlet portion and the outlet portion. Each atomizer is disposed at least partially within the housing such that the outlet portion of each atomizer is in fluid communication with the flow path. The housing is configured such that a gas flowing at a first location within the flow path has an axial velocity component having a first direction and the gas flowing at a second location within the flow path has an axial velocity component having a second direction substantially opposite the first direction. The separator is configured to receive a mixture of the gas and the solution and produce a first outlet flow and a second outlet flow. The first outlet flow includes a portion of the gas and a vaporized portion of a solvent from the solution. The second outlet flow includes a liquid portion of the solvent from the solution and a solute from the solution.

In some embodiments, an atomizer can be configured to mix a portion of an inlet solution with a portion of a gas flow. For example, in some embodiments, an apparatus includes an atomizer, a housing and a separator. The atomizer defines a liquid flow path and a gas flow path. The liquid flow path is fluidically coupled to a source of a solution such that a portion of the solution from the source of the solution can be conveyed to the atomizer via the liquid flow path. The gas flow path is fluidically coupled to a source of inlet gas such that a first portion of an inlet gas from the source of inlet gas can be conveyed to the atomizer via the gas flow path. The atomizer is configured to mix the portion of the solution and the first portion of the inlet gas to produce an atomized mixture of the solution and the first portion of the inlet gas. The housing has an inlet portion and an outlet portion, and defines a flow path between the inlet portion and the outlet portion. The inlet portion of the housing is fluidically coupled to the source of inlet gas such that a second portion of the inlet gas from the source of inlet gas can be conveyed into the flow path via the inlet portion of the housing. The atomizer is disposed at least partially within the housing such that the second portion of the inlet gas can be mixed with the atomized mixture. The separator is configured to receive the mixture of the second portion of the inlet gas and the atomized mixture and produce a first outlet flow and a second outlet flow. The first outlet flow includes a vaporized portion of a solvent from the solution. The second outlet flow includes a liquid portion of the solvent from the solution and a solute from the solution.

In some embodiments, an apparatus includes an atomizer assembly including an injection member and an outlet nozzle. The atomizer assembly is configured to mix an inlet flow of a solution and an inlet gas to produce an atomized mixture of the solution and the inlet gas. The injection member is configured to receive an inlet flow of a solution, which can be, for example, source water. The injection member defines a liquid flow path and a mixing volume. The injection member is configured such that a portion of the solution is conveyed to the mixing volume via the liquid flow path. At least a portion of the outlet nozzle is spaced apart from the injection member such that the outlet nozzle and the injection member collectively define a gas flow path. The inlet gas is conveyed to the mixing volume via the gas flow path.

In some embodiments, an apparatus includes an atomizer configured to mix an inlet flow of a solution and an inlet gas to produce an atomized mixture of the solution and the inlet gas. The injection member is configured to receive an inlet flow of a solution, which can be, for example, source water. An inner surface of the atomizer defines a liquid flow path through which at least a portion of the solution flows. An outer surface of the atomizer defines at least a portion of a gas flow path. In some embodiments, the outer surface includes a flow member configured to change a direction of flow of the gas.

The term "atomize" is used herein to describe the process of reducing a liquid or solution into a series of tiny particles, droplets and/or a fine spray. For example, as used herein, a device or component configured to atomize a liquid and/or produce and atomized flow of a liquid can be any suitable device or component that reduces and/or "breaks" the liquid into a series of tiny particles and/or a fine spray.

FIG. **1** is a schematic illustration of a water desalinization system **1000** according to an embodiment. The system **1000** includes a water processor **1100**, a separator **1300**, a condenser assembly **1400**, an air-processing subsystem **1500** and a water inlet assembly **1600**. As described in more detail herein, the system **1000** is configured to receive an inlet flow of water containing a solute (e.g., seawater) and produce a flow of water substantially free of the solute (e.g., desalinated water, or water that is free other dissolved solids). In particular, inlet seawater S_{in} and inlet air G_{in} are mixed by the water processor **1100** to form a mixture of air, water vapor and concentrated brine solution (the mixture is identified by the reference character G_2 in FIG. **1**). The mixture G_2 is then separated by the separator **1300** to produce a gaseous flow of water vapor VAP (i.e., substantially saturated air) and a flow of waste products WASTE, including the solute, dissolved solids, and/or brine. The water vapor VAP is condensed within the condenser assembly **1400** to produce a flow of water substantially free of the solute (e.g., desalinated water; identified as process water P in FIG. **1**). The waste products WASTE (e.g., the brine) is discharged in near solid form for disposal. As discussed below, the desalinization system **1000** is configured to recycle the thermal energy resulting from the condensation of the water vapor VAP to improve the efficiency of the system.

The water inlet assembly **1600** includes a pump **1610**, a supply manifold **1626**, inlet pipe **1620**, and a set of supply lines **1640**. The water inlet assembly **1600** also includes the associated plumbing within which the inlet (or feed) water S_{in} is conveyed. As shown in FIG. **1**, the water inlet assembly **1600** includes a strainer **1602** that can be submerged within a source of the inlet feed water S_{in}. The strainer **1602** can be any suitable strainer or filter for removing particles or large debris from the inlet feed water S_{in}. The water is conveyed from the source of the inlet water to the pump **1610** via the inlet piping **1620**.

The pump **1610** can be any suitable fluid machine for producing a flow of the inlet feed water S_{in} within the inlet piping **1620** and into the processor **1100**. Similarly stated, the pump **1610** produces a flow of inlet feed water S_{in} to the condenser assembly **1400** via the portion of the inlet piping **1621**. In some embodiments, the source of inlet feed water S_{in} can include a reservoir (not shown in FIG. **1**) within which the pump **1610**, the inlet piping **1620** and/or the strainer **1602** are, at least partially, disposed. Similarly stated, in some embodiments, the pump **1610** can be disposed beneath the surface of the inlet feed water S_{in}.

In some embodiments, the pump **1610** can be a centrifugal pump that produces a flow of the inlet feed water S_{in} having a flow rate of between 0.05 gallons per minute and 2 gallons per minute and a pressure of between 2 p.s.i. and 10 p.s.i. Although the water inlet assembly **1600** is shown in FIG. **1** as including only one pump **1610**, in other embodiments, the water inlet assembly **1600** can include any number of pumps. For example, in some embodiments, a water inlet assembly **1600** can include a first pump located within the source of the inlet feed water S_{in} (e.g., a lift pump) and a second pump located adjacent the processor **1100**, which produces a high pressure flow to the processor **1100**. In other embodiments, the water inlet assembly **1600** can include a series of pumps that provide a flow of inlet water to different portions of the water processor **1100** in parallel. For example, in some embodiments, the pump **1620** can be a multichannel peristaltic metering pump configured to supply a flow of inlet water to a different atomizer and/or injection port within the water processor **1100**.

In some embodiments, the water inlet assembly **1600** can include a controller (not shown in FIG. **1**) that can adjust the flow rate produced by the pump **1610**. In such embodiments, the controller can be adjusted manually (i.e., directly via human intervention). In other embodiments, the controller can be an automatic controller that is adjusted, for example, based upon feedback and/or measurements taken from other portions of the water desalinization system **1000**. In some embodiments, for example, a controller can be configured to adjust the flow rate produced by the pump **1610** to ensure that the flow of waste products WASTE has sufficient liquidity to be conveyed from the system **1000**.

As shown in FIG. **1**, the inlet feed water S_{in} is conveyed from the pump **1610** to the condenser **1400** via the portion of inlet piping **1621**. A portion of the inlet piping **1622** is disposed within the condenser **1400** such that thermal energy can be transferred from the gas flow within the condenser **1400** (i.e., the gaseous flow of water vapor VAP) to the inlet feed water S_{in} when the inlet feed water S_{in} flows through the portion of the inlet piping **1622**. Similarly stated, the portion of the inlet piping **1622** is disposed within the condenser **1400** such that the heat removed from the gaseous flow VAP is transferred into the inlet feed water S_{in}, thereby raising the temperature of the inlet feed water S_{in} above an ambient temperature. The portion of the inlet piping **1622** can be coupled to or cooperatively function with any suitable structure and/or mechanism to enhance the condensation of the gaseous flow VAP and/or the heat transfer into the inlet feed water S_{in}. For example, in some embodiments, the portion of the inlet piping **1622** can be coupled to a series of heat transfer fins. In other embodiments, the portion of the inlet piping **1622** can be configured with a series of bends to increase the length of travel of the inlet feed water S_{in} within the condenser **1400**.

The inlet feed water S_{in} is conveyed from the condenser **1400** to the supply manifold **1626** via a portion of the inlet piping **1623**, as shown by the arrows AA in FIG. **1**. The supply manifold **1626** includes a series of outlet ports **1627**, each of which is in fluid communication with a corresponding atomizer **1200** of the water processor **1100** via a supply tube **1640**. In some embodiments, the water inlet assembly **1600** can include one or more controllers and/or valves (not shown in FIG. **1**) to adjust the pressure and/or flow rate of the inlet feed water S_{in} to the water processor **1100** and/or each of the atomizers **1200**.

In some embodiments, the supply manifold **1626** can include any suitable mechanism for conditioning or further processing the inlet feed water S_{in}. For example, in some embodiments, the water inlet assembly **1600** can include a pump or other device for producing pressure within the supply manifold **1626** such that the pressure and/or flow of the inlet feed water S_{in}, supplied to each of the atomizers is within a predetermined range. In some embodiments, the supply manifold **1626** can include an accumulator or movable member configured to accumulate, dampen and/or store pressure energy within the inlet feed water S_{in}, thereby producing a constant flow and/or pressure to the water processor **1100**. In other embodiments, the supply manifold **1626** can include a heater (not shown in FIG. **1**) to further heat the inlet feed water S_{in}.

The air processing subsystem **1500** is configured to circulate air within the water desalinization system **1000**. As described herein, a first portion of the inlet air G_{in}, which is substantially dry (i.e., substantially free of moisture content), is conveyed into the atomizer plenum **1120** of the water processor **1100** where it is mixed with the flow of inlet feed water S_{in} from the first and second atomizers **1200** to produce an atomized flow of the inlet feed water S_{in}. The atomized flow of the inlet feed water S_{in} is identified in FIG. **1** as the flow S_1 and S_2, produced by the first and second atomizers **1200**, respectively. A second portion of the inlet air G_{in} is conveyed into the evaporation plenum **1130** of the water processor **1100** where it is mixed with the atomized flow S1 and S2 such that inlet feed water S_{in} is evaporated into the inlet air G_{in}. In this manner, a mixture of air, water vapor and concentrated brine solution (the mixture is identified by the reference character G_2 in FIG. **1**) is produced. In this manner, the inlet air G_{in} absorbs the inlet feed water S_{in} and conveys the inlet feed water S_{in} through the system **1000**.

The air processing subsystem **1500** includes an air pump **1510**, an air inlet plenum **1516** (which includes an external air inlet port **1511**), and an air return plenum **1518**. The air pump **1510** can be any suitable fluid machine for producing a pressure and/or flow of air through the system **1000**, as described herein. More particularly, the air pump **1510** compresses the inlet air G_{in} from external air inlet port **1511** and/or air return plenum **1518** such that the inlet air G_{in} is conveyed into the water processor **1100**, as shown by the arrow BB in FIG. **1**. In some embodiments, the air pump **1510** is a centrifugal pump or blower that produces a flow of the inlet air G_{in} having a flow rate of between 30 cubic feet per minute and 3000 cubic feet per minute and a pressure of between 3 p.s.i. and 10 p.s.i. In some embodiments, the air pump **1510** can produce a pressurized airflow within the plenum **1516** having a pressure of approximately 5 p.s.i. at a flow rate of approximately 300 cubic feet per minute. The air pump **1510** can be any suitable pump, such as for example, a Rotex C30-74 supercharger. Although the air pump **1510** is shown and described as producing a pressure of less than 10 p.s.i., in other embodiments, the air pump **1510** can produce any desired range of pressure.

The air pump **1510** can be driven by any suitable mechanism, such as, for example, by an electric motor (not shown in FIG. **1**). In other embodiments, the air pump **1510** can be driven by a fluid machine (e.g., a turbine powered by shop air or the like).

The air circuit is a substantially closed system to conserve kinetic energy and reduce the noise level associated with the air pump **1510** and the flow of the inlet air G_{in} throughout the system. The air inlet plenum **1516**, however, includes an external air inlet port **1511**, from which external air (e.g., "make-up air") can be drawn. In other embodiments, however, the air processing subsystem **1500** can include an external inlet port in any suitable location.

The water processor **1100** includes a housing **1110** (or other suitable structure that defines one or more enclosures), a series of atomizers **1200**, and a series of vaporizers (or evaporators) **1270**. A baffle **1140** is disposed within the housing **1110** to divide the housing **1110** into the atomizer plenum **1120** and the evaporation plenum **1130**.

Each of the atomizers **1200** is disposed, at least partially, within the atomizer plenum **1120**. The atomizers **1200** are configured to receive a portion of the inlet feed water S_{in} and a portion of the inlet air G_{in} to produce an atomized flow of the inlet feed water S_1 and S_2. More particularly, each atomizer **1200** receives heated inlet feed water S_{in} from the water inlet assembly **1600**, as described above. Each atomizer **1200** also receives a portion of the inlet air G_{in} from the air processing subassembly **1500**, as described above. The atomizers **1200** are configured to mix the inlet feed water S_{in} and the inlet air G_{in}, as shown by the arrow CC in FIG. **1**, to produce an atomized flow and/or fine spray of the inlet feed water S_1 and S_2. In this manner, the atomizers **1200** produce a flow of small water droplets and water vapor suspended in the process air. The small water droplets have a greater ratio of surface area to volume, which facilitates evaporation, as described below. The atomized flow S_1 and S_2 from each of the atomizers **1200** is conveyed into the evaporation plenum **1130** through an opening and/or nozzle, as shown by the arrows DD. Although the atomizers **1200** are shown and described as being configured to mix the inlet solution S_{in} with a portion of the inlet air G_{in} supplied by the air processing subsystem **1500**, in other embodiments, the atomizers **1200** can be configured to atomize the inlet feed water S_{in} without mixing the inlet feed water S_{in} with a portion of the inlet air G_{in}. For example, in some embodiments, the atomizers **1200** can be configured to produce an atomized spray of the inlet feed water S_{in} by high-pressure injection.

Each of the vaporizers **1270** is disposed, at least partially, within the evaporation plenum **1130**. The vaporizers **1270** are configured to receive the atomized flow of the inlet feed water S_1 and S_2 and mix the atomized flow S_1 and S_2 with the second portion of the inlet air G_{in} to produce the substantially vaporized mixture G_2. The vaporizers **1270** can include any suitable structure and/or mechanisms to promote vaporization of the atomized flow S_1 and S_2. For example, in some embodiments, the vaporizers **1270** can include a circulation flow path to allow the atomized flow S_1 and S_2 sufficient time and/or length of travel to mix with the inlet air G_{in}. In other embodiments, the vaporizers **1270** can include a heater to promote vaporization of the atomized flow S_1 and S_2.

The evaporation plenum **1130** defines, at least in part, a flow path **1134** within which the inlet air G_{in} and/or the atomized flow S_1 and S_2 from each of the atomizers **1200** can flow to each of the vaporizers **1270**. Moreover, the vaporizers **1270** and the evaporation plenum **1130** can be configured such that the flow path **1134** flows through and/or includes each of the vaporizers **1270**. Moreover, each atomizer **1200** is disposed, at least partially, within the baffle **1140** such that the outlet portion of each atomizer **1200** is in fluid communication with the flow path **1134** and/or the corresponding vaporizer **1270**.

In use, the evaporation plenum **1130** receives a portion of the inlet air G_{in} provided by the air processing subassembly **1500** via an opening **1141** defined by the baffle **1140**, as shown by the arrow BB'. The inlet solution S_1 is mixed with the substantially dry inlet air G_{in} provided by the air processing subsystem **1500**, as described above. The inlet solution S2 is then mixed with the mixture G_1 of the inlet air G_{in} and the inlet solution S_1. Thus, the evaporation plenum **1130** of the housing **1110** is configured such the inlet air G_{in} flowing within the flow path **1134** is sequentially mixed with the atomized flow of the solution produced by each atomizer **1200** to produce a substantially vaporized mixture of the air and the solution G_2.

The separator **1300** is fluidically coupled to the outlet portion of the processor **1100** such that the substantially vaporized mixture G_2 flows from the processor **1100** into the separator **1300**, as indicated by arrow EE. The separator produces a first outlet flow and a second outlet flow. The first outlet flow includes a portion of the air G_{in} and the vaporized portion VAP of the solvent (e.g., water) from the inlet feed water S_{in}. The first outlet flow VAP is then conveyed to a condenser assembly **1400**, as indicated by arrow FF. The second outlet flow includes a liquid portion LIQ of the solvent from the solution and the solute WASTE from the solution. The second outlet flow is then conveyed to a volume substantially outside the system, as indicated by arrow GG. In this manner, the separator **1300** separates the solute from the solution.

The separator **1300** can include any structure and/or mechanism to separate the vaporized portion VAP of the solvent and the solute WASTE. In some embodiments, for example, the separator **1300** can include a series of structures and/or define a tortuous path to separate the heavier solute from the vapor. In other embodiments, the separator **1300** can include a centrifugal separation mechanism to separate the heavier solute from the vapor.

The condenser assembly **1400** includes a housing **1410**, a condenser element **1430** (disposed within the housing **1410**), and a heat pipe **1450**. As described above, housing **1410** defines an interior volume that receives the first outlet flow VAP, as indicated by arrow FF. The condenser **1400** includes any structure and or mechanisms to transfer thermal energy between the relatively hot first outlet flow VAP and the relatively cool ambient conditions (e.g., the inlet feed water S_{in}). Similarly stated, the condenser element **1430** condenses the vaporized portion VAP of the solvent to produce the flow of process water P (indicated by arrow HH in FIG. **1**) that is substantially free of the solute. As described above, a portion of the inlet piping **1622** of the water inlet assembly **1600** is disposed within the housing **1410** and/or the condenser element **1430** such that heat is transferred from the first outlet flow VAP to the inlet feed water S_{in}. In addition to removing heat from the condenser assembly **1400** and/or condenser element **1430**, warming the inlet feed water S_{in} also allows for a more rapid absorption of the atomized flow S_1 and S_2 respectively.

As shown in FIG. **1**, the condenser element **1430** is configured to interact with the heat pipe **1450**. The heat pipe **1450** can be any suitable heat pipe of known configuration that transfers heat between the condenser assembly **1400** and the processor assembly **1100**, and more particularly the evaporation plenum **1130** of the processor assembly **1100**. The heat pipe **1450** can be, for example, a gravity action heat pipe, a capillary action heat pipe or the like. The heat pipe **1450** has a first end portion **1452** and a second end portion **1454**, and a substantially adiabatic section **1453** there between. The heat pipe **1450** contains a working fluid **1455**, such as for example, water, acetone, ammonia, ethanol, and/or any other suitable fluid. The first end portion **1452** (i.e., the condenser end) is disposed within the condenser assembly **1400** and/or is coupled to the condenser element **1430**. The second end portion **1454** (i.e., the evaporator end) is disposed within the evaporation plenum **1130**.

In use, the first outlet flow VAP is conveyed to the condenser element **1430** of the condenser assembly **1400** and, either directly or indirectly, to the first end portion **1452** of the heat pipe **1450**. When the first outlet flow VAP flows across the evaporator end **1452** of the heat pipe **1450**, heat is transferred from the first outlet flow VAP to the evaporator end **1452** of the heat pipe **1450** (and subsequently the heat pipe working fluid **1455**) and/or the condenser element **1430**. The heat transfer causes the heat pipe working fluid **1455** to boil and liquid process water P to form, as mentioned above. The heat pipe working fluid **1455** boils at the temperature of first outlet flow VAP because the heat pipe **1450** is sealed and evacuated below atmospheric pressure. When the heat pipe working fluid **1455** is in the vapor phase, the vapor flows through a substantially adiabatic section **1453** of the heat pipe **1450** to the condenser end **1454**, as shown by the arrow II. When the vaporized heat pipe working fluid **1455** is in the condenser end **1454**, heat is transferred from the vaporized heat pipe working fluid **1455** to the body of the heat pipe **1450** and subsequently to the fluid (e.g., the inlet air Gin and/or the mixture G_2) within the processor **1100**. This transfer of heat increases the temperature of the fluid flowing within the processor assembly **1100** (thereby increasing the amount of the flow S_1 and S_2 that can be absorbed into the air G_{in} and/or G_1, respectively) and condenses the heat pipe working fluid **1455** back into a substantially liquid phase. The heat pipe working fluid **1455** then returns to heat pipe evaporator end **1452**.

Thus, the heat pipe **1450** enhances the efficiency of the condenser **1400** and the vaporization process within the processing assembly **1100**. Although the second end portion **1454** is shown and described as conveying heat to the evaporation plenum **1130**, in other embodiments, the heat pipe **1450** can be configured to transfer heat to the atomizer plenum **1120**, and/or the air processing subsystem **1500**. Furthermore, the heat pipe **1450** can be configured as a loop style heat pipe, allowing the heat pipe working fluid **1455** to flow continuously between the various zones of high and low temperatures.

In some embodiments, the water desalinization system **1000** can include a control system (not shown in FIG. **1**) to control the flow of air and or water within certain portions of the system. For example, the control system can include a set of components such as pressure sensors and adjustable valves to monitor and/or control the flow rate and pressure of air through the air pump **1510**. Similarly, the flow rate, pressure, and/or saturation of the solution entering or exiting the atomizers **1200** and/or vaporizers **1270** can be controlled. In this manner, the saturation level of the mixture G_2 can be monitored and controlled either manually (i.e., direct user control) or via feedback using the control system.

FIG. **2** is a schematic illustration of a processor system **2100** according to an embodiment. As described herein, the processor system **2100** is configured to produce a mixture of a solution S_{in} and an inlet air G_{in} (the mixture is identified in FIG. **2** as mixture G_1 or mixture G_2). The processor system **2100** is further configured to produce a gaseous flow of vapor VAP (i.e., air that is substantially saturated with the liquid portion of the solution S_{in}) and a flow of waste products (identified in FIG. **2** as WASTE). The processor system **2100** can be included within any suitable liquid purification system of the types shown and described herein, such as, for example, the water desalinization system **1000** shown and described above.

The processor system **2100** includes a housing **2110**, a series of atomizers **2200** and a separator **2300**. Each atomizer **2200** has an inlet portion **2210** and an outlet portion **2240**. The inlet portion **2210** of each atomizer **2200** is configured to receive an inlet flow of a solution S_{in} as shown by the arrows JJ. The inlet flow of solution S_{in} can be conveyed to the atomizers **2200** via any suitable mechanism, such as for example, by a series of supply lines (each of which corresponds to one of the atomizers **2200**), an inlet manifold, or the like. The solution S_{in} can be any suitable solution of a solvent containing a solute. In some embodiments, for example, the solution can be a solution of water (the solvent) and salt, dissolved solids or the like (the solute). Similarly stated, in some embodiments, the solution can be seawater, brackish water or the like.

The outlet portion **2240** of each atomizer **2200** is configured to produce an atomized flow of the solution S_{in}. Similarly stated, the atomizer **2200** and/or outlet portion **2240** is configured to produce a spray including small particles of the solution S_{in}. In particular, the atomized portion of the solution S_{in} produced by the outlet portion **2240** of the first atomizer is identified as S_1 and the atomized portion of the solution S_{in} produced by the outlet portion **2240** of the second atomizer is identified as S_2. The atomizer **2200** can atomize the solution S_{in} using any suitable mechanism. For example, in some embodiments, the atomizer **2200** can include and/or define an orifice and/or a nozzle through which the solution S_{in} flows in a manner to produce a spray including small particles of the solution S_{in}. In some embodiments, the atomizer **2200** can convert the pressure energy of the inlet flow of the solution S_{in} to facilitate the atomization process. Such "pressure-driven" configurations can operate at any suitable pressure level, such as, for example a solution pressure of greater than 20 psi, greater than 50 psi, greater than 100 p.s.i. and/or greater than 200 p.s.i. In other embodiments, the atomizer **2200** can be an "air-assisted" atomizer that mixes the inlet flow of the solution S_{in} with an airflow to facilitate the atomization process. Although FIG. **2** is shown as having a pair of atomizers, in other embodiments, the processor system **2100** can have any suitable number of atomizers **2200**.

The housing **2110** includes an inlet portion **2122** that receives a gas G_{in}, and an outlet portion **2135**. The housing **2110** defines a flow path **2134** between the inlet portion **2122** and the outlet portion **2135**. As shown in FIG. **2**, each atomizer **2200** is disposed, at least partially, within the housing **2110** such that the outlet portion **2240** of each atomizer **2200** is in fluid communication with the flow path **2134**. This arrangement permits the gas G_{in} flowing within the flow path **2134** to be sequentially mixed with the atomized flow of the solution S_{in} produced by each of the atomizers **2200**.

More particularly, in use the housing **2110** receives an inlet gas G_{in}, having an initial humidity ratio of ω_{in} via the inlet portion **2122**, as indicated by arrow KK. The inlet gas G_{in} flows within the flow path **2134** and is mixed with the atomized flow of solution S_1 produced by the first atomizer **2200**. A mixture of the gas G_{in} and the portion of the solution S_1 (identified as the mixture G_1) is produced, having a humidity ratio ω_1 that is greater than the initial humidity ratio ω_{in}. The gas mixture G_1 is then mixed with the atomized flow of the solution S_2 produced by the second atomizer **2200** to produce a mixture that includes the portion of the solution S_2 (identified as the mixture G_2) having a humidity ratio ω_2 that is greater than the initial humidity ratio ω_{in} and the humidity ratio ω_1. Said a different way, the housing **2110** and the atomizers **2200** are collectively configured to sequentially mix the inlet gas G_{in} with atomized flow produced by each atomizer **2200** in series (i.e., at a different time and/or a different spatial location within the flow path **2134**) such that the humidity ratio ω increases as the gas solution mixture flows past each successive atomizer **2200**. In this manner, the inlet solution S_{in} is mixed with and/or atomized into the inlet gas G_{in} flow to produce a mixture having a desired humidity ratio that is subsequently conveyed into the separator **2300**, as described below.

The separator **2300** is fluidically coupled to the outlet portion **2135** of the housing **2110** such that the separator **2300** receives the mixture of the gas and solution from the outlet portion **2135** as indicated in FIG. **2** by arrow LL. The separator **2300**, which has a first outlet portion **2331** and second outlet portion **2332**, is configured to produce a first outlet flow and a second outlet flow. More particularly, the first outlet flow includes a portion of the gas G_{in} and a vaporized portion VAP of the solvent. The second outlet flow includes a liquid portion LIQ of the solvent and the solute WASTE (i.e., the solid waste) from the solution. As shown in FIG. **2**, the first outlet flow, including a portion of the gas G_{in} and the vaporized portion VAP of the solvent, can be conveyed, via the first outlet portion **2331**, to any suitable condenser (not shown in FIG. **2**) as shown by the arrow MM. The second outlet flow, including the liquid portion LIQ of the solvent and the solute WASTE, can be conveyed, via the second outlet portion **2332**, to a volume substantially outside the system, as indicated by arrow NN in FIG. A**1**. In this manner, the separator **2300** separates the solute from the solution. Similarly stated, in embodiments in which the solution is seawater, the separator **2300** separates the salt and/or total dissolved solids from the water, thereby producing a substantially purified water vapor. The separator **2300** can use any suitable mechanism for separating the solute from the solution, such as a tortuous path, a filter, a rotating member, an electrically charged member and/or the like.

FIG. **3** is a schematic illustration of a processor system **3100** according to an embodiment. As described herein, the processor system **3100** is configured to produce a mixture of a solution S_{in} and a gas G_{in} (the mixture is identified in FIG. **3** as mixture G_1, G_2, G_3, and/or G_4). The processor system **3100** is further configured to produce a gaseous flow of vapor VAP (i.e., air that is substantially saturated with the liquid portion of the solution S_{in}) and a flow of waste products (identified in FIG. **3** as WASTE). The processor system **3100** can be included within any suitable liquid purification system of the types shown and described herein.

The processor system **3100** includes a housing **3110**, a series of atomizers **3200**, and a separator **3300**. Each atomizer **3200** has an inlet portion **3210** and an outlet portion **3240**. The inlet portion **3210** of each atomizer is configured to receive an inlet flow of a solution S_{in}, as shown by the arrows RR. The solution S_{in} can be any suitable solution of a solvent containing a solute. In some embodiments, for example, the solution can be of water (the solvent) and salt, dissolved solids or the like (the solute). The inlet portion **3210** receives the solution S_{in} using any suitable mechanism described herein.

The outlet portion **3240** of each atomizer **3200** is configured to produce an atomized flow of the solution S_{in}. Similarly stated, the atomizer **3200** and/or outlet portion **3240** is configured to produce a spray including small particles of the solution S_{in}. In particular, the atomized portion of the solution S_{in} produced by the outlet portion **3240** of the first atomizer is identified as S_1, the atomized portion of the solution S_{in} produced by the outlet portion **3240** of the second atomizer is identified as S_2, the atomized portion of the solution S_{in} produced by the outlet portion **3240** of the third atomizer is identified as S_3 and the atomized portion of the solution S_{in} produced by the outlet portion **3240** of the fourth atomizer is identified as S_4. The atomizers **3200** can atomize the solution S_{in} using any suitable mechanism. For example, in some embodiments, the atomizers **3200** can include and/or define an orifice and/or a nozzle through which the solution S_{in} flows in a manner to produce a spray including small particles of the solution S_{in}. In some embodiments, the atomizers **3200** can convert the pressure energy of the inlet flow of the solution S_{in} to facilitate the atomization process. Although FIG. **3** is shown as having four atomizers, in other embodiments, the processor system **3100** can have any suitable number of atomizers **3200**.

The housing **3110** includes an inlet portion **3122** that receives a gas G_{in} and an outlet portion **3135**. The housing **3110** defines a flow path **3134** between the inlet portion **3122** and the outlet portion **3135**. As shown in FIG. **3**, each atomizer **3200** is disposed, at least partially, within the housing **3110** such that the outlet portion **3240** of the atomizer **3200** is in fluid communication with the flow path **3134**. This arrangement permits the gas G_{in} flowing within the flow path **3134** to be sequentially mixed with the atomized flow of the solution S_{in} produced by each of the atomizers **3200**.

The housing **3110** is configured such that the inlet portion **3210** receives an inlet gas G_{in} having an initial humidity ratio of ω_{in}, as indicated by arrow PP in FIG. **3**. The housing **3110** directs the inlet gas G_{in} to flow within the flow path **3134** toward a first mixing location L_1. The inlet gas G_{in} is first mixed with the atomized flow of solution S_1 produced by the first atomizer **3200**. A first mixture of the gas G_{in} and the atomized portion of the solution S_1 (identified as mixture G_1) is produced, having a humidity ratio ω_1, that is greater than the humidity ratio ω_{in}, and having an axial velocity component in a first direction QQ. The first atomizer **3200** is disposed in the housing **3110** such that the atomized portion of the solution S_1 flows in the first direction QQ. Similarly stated, the flow of the solution S_1 and the flow of the gas G_{in} in the flow path **3134** are in substantially the same direction at a first mixing location L_1. The mixture G_1 then flows within the flow path **3134** toward a second mixing location L_2. The housing **3110** is configured such that the flow of the mixture at the second mixing location L_2 (indicated by the arrow SS) has a flow direction that is substantially opposite the first direction QQ. The gas G_1 is mixed, at the second mixing location L_2, with the atomized flow of solution S_2 produced by the second atomizer **3200** to produce a second mixture of the gas G_1 and the atomized portion of the solution S_2 (identified as mixture G_2), having a humidity ratio ω_2, that is greater than the humidity ratio ω_1, and having an axial velocity component in a second direction SS. The mixture G_2 then flows within the flow path **3134** toward a third mixing location L_3. The housing **3110** is configured such that the flow of the mixture at the third mixing location L_3 is in the first direction (as indicated by the arrow QQ). The gas G_2 is mixed, at the third mixing location L_3, with the atomized flow of the solution S_3 produced by the third atomizer **3200** to produce a third mixture of the gas G_2 and the atomized portion of the solution S_3 (identified as mixture G_3), having a humidity ratio ω_3, that is greater than the humidity ratio ω_2, and having an axial velocity component in the first direction QQ. The mixture G_3 then flows within the flow path **3134** toward a fourth mixing location L_4. The housing **3110** is configured such that the flow of the mixture at the fourth mixing location L_4 is in the second direction (as indicated by the arrow SS). The gas G_3 is mixed, at the fourth mixing location L_4, with the atomized flow of the solution S_4 produced by the fourth atomizer **3200** to produce a fourth mixture of the gas G_3 and the atomized portion of the solution S_4 (identified as mixture G_4), having a humidity ratio ω_4, that is greater than the humidity ratio ω_3, and having an axial velocity component in the first direction QQ. Said a different way, the atomizers **3200** are positioned in the housing **3110** such that the flow of the atomized portion of the solution S_1, S_2, S_3, and S_4, respectively, is in the same direction of the flow path **3134** at each mixing location, L_1, L_2, L_3, L_4 respectively, as shown in FIG. **3**.

The housing **3110** is configured such that the flow path **3134** produces a flow therein that alternates between the first direction QQ and the second direction SS, changing directions before each subsequent mixture. Similarly stated, the gas G_{in} enters the inlet portion **3122** and flows within the flow path **3134** to the first mixing location L_1 where the gas G_{in} and/or the mixture G_1 flows in the first direction QQ. The housing **3110** is configured to direct the flow path **3134** in the second direction SS, substantially opposite of the first direction QQ, before the flow path **3134** reaches the second mixing location L_2. The housing **3110** is configured such that the mixture G_2 flows in the first direction QQ before the flow path **3134** reaches the third mixing location L_3.

Although FIG. **3** shows the flow paths in parallel and opposite directions, in other embodiments the housing **3110** can be configured to direct the fluid flow therein in any suitable manner that will reduce the length L of the housing **3110** while maintaining the efficiency of the mixing and/or vaporization of the inlet as G_{in} and the solution S_{in}. In some embodiments, the housing **3110** can be configured such that two or more atomizers **3200** are disposed, at least partially, within the housing **3110** in the same direction of the flow path **3134** at a given location (i.e., L_1, L_2, L_3 L_4). In this arrangement the inlet gas G_{in} can be mixed with more than one atomized flow of the solution S_{in}. Furthermore, while FIG. **3** shows the processor system **3100** having four atomizers **3200**, in other embodiments, the processor system **3100** can have any suitable number of atomizers **3200** and the housing **3110** can be configured to change the direction of the flow before each of the respective atomizers **3200**.

The separator **3300** is fluidically coupled to the outlet portion **3135** of the housing **3110** such that the separator **3300** receives the mixture of the gas and solution from the outlet portion **3135** as indicated in FIG. **3** by arrow TT. The separator **3300**, which has a first outlet portion **3331** and a second outlet portion **3332**, is configured to produce a first outlet flow and a second outlet flow. More particularly, the first outlet flow includes a portion of the gas G_{in} and a vaporized portion

VAP of the solvent. The second outlet flow includes a liquid portion LIQ of the solvent and the solute WASTE (i.e., the solid waste) from the solution. As shown in FIG. **3**, the first outlet flow, including a portion of the gas G_{in} and the vaporized portion VAP of the solvent, can be conveyed, via the first outlet portion **3331**, to any suitable condenser (not shown in FIG. **3**) as shown by the arrow UU. The second outlet flow, including the liquid portion LIQ of the solvent and the solute WASTE, can be conveyed, via the second outlet portion **3332**, to a volume substantially outside the system, as indicated by arrow VV. In this manner, the separator **3300** separates the solute from the solution. Similarly stated, in embodiments in which the solution is seawater, the separator **3300** separates the salt and/or total dissolved solids from the water, thereby producing a substantially purified water vapor. The separator **3300** can use any suitable mechanism for separating the solute from the solution, such as a tortuous path, a filter, a rotating member, an electrically charged member and/or the like.

FIG. **4** is a schematic illustration of a processor system **4100** according to an embodiment. As described herein, the processor system **4100** is configured to produce a mixture of a solution S_{in} and a gas G_{in} (the mixture is identified in FIG. **4** as mixture G_1, G_2, and/or G_3). The processor system **4100** is further configured to produce a gaseous flow of vapor VAP (i.e., air that is substantially saturated with the liquid portion of the solution S_{in}) and a flow of waste products (identified in FIG. **4** as WASTE). The processor system **4100** can be included within any suitable liquid purification system of the types shown and described herein.

The processor system **4100** includes a housing **4110**, a series of atomizers **4200**, and a separator **4300**. Each atomizer **4200** has an inlet portion **4210** and an outlet portion **4240**. The inlet portion **4210** of each atomizer is configured to receive an inlet flow of a solution S_{in}, as shown by the arrows WW. The solution S_{in} can be any suitable solution of a solvent containing a solute. In some embodiments, for example, the solution can be of water (the solvent) and salt, dissolved solids or the like (the solute). The inlet portion **4210** receives the solution S_{in} using any suitable mechanism described herein.

The outlet portion **4240** of each atomizer **4200** is configured to produce an atomized flow of the solution S_{in}. Similarly stated, the atomizer **4200** and/or outlet portion **4240** is configured to produce a spray including small particles of the solution S_{in}. In particular, the atomized portion of the solution S_{in} produced by the outlet portion **4240** of the first atomizer is identified as S_1, the atomized portion of the solution S_{in} produced by the outlet portion **4240** of the second atomizer is identified as S_2 and the atomized portion of the solution S_{in} produced by the outlet portion **4240** of the third atomizer is identified as S_3. The atomizer **4200** can atomize the solution S_{in} using any suitable mechanism. For example, in some embodiments, the atomizer **4200** can include and/or define an orifice and/or a nozzle through which the solution S_{in} flows in a manner to produce a spray including small particles of the solution S_{in}. In some embodiments, the atomizer **4200** can convert the pressure energy of the inlet flow of the solution S_{in} to facilitate the atomization process. In other embodiments, the atomizer **4200** can be an "air-assisted" atomizer that mixes the inlet flow of the solution S_{in} with an airflow to facilitate the atomization process. Although FIG. **4** is shown as having three atomizers, in other embodiments, the processor system **4100** can have any suitable number of atomizers **4200**.

The housing **4110** includes an inlet portion **4122** that receives a gas G_{in} and an outlet portion **4135**. The housing **4110** defines a flow path **4134** between the inlet portion **4122** and the outlet portion **4135**. As shown in FIG. **4**, each atomizer **4200** is disposed, at least partially, within the housing **4110** such that the outlet portion **4240** of the atomizer **4200** is in fluid communication with the flow path **4134**. This arrangement permits the gas G_{in} flowing within the flow path **4134** to be sequentially mixed with the atomized flow of the solution S_{in} produced by each of the atomizers **4200**.

The housing **4110** is configured such that the inlet portion **4122** receives a flow of gas G_{in} having an initial humidity ratio of ω_{in} and characterized by a first axial flow direction and rotational flow direction, collectively indicated by arrow A_1 in FIG. **4**. More specifically, the gas G_{in} flowing within the inlet portion **4122** includes an axial velocity component and a rotational velocity component (about the axis defining the axial velocity component) that are collectively identified as the first axial and rotational direction A_1. The rotational direction can be in a counterclockwise direction, as shown in FIG. **4**, or a clockwise direction according to some embodiments. Furthermore, the first axial and rotational direction A_1 can be inherent to the flow of the inlet gas G_{in} before the inlet gas G_{in} enters the housing **4110** (i.e., produced by a gas source not shown in FIG. **4**), or can be produced by the inlet portion **4122** via a nozzle, turbine, orifice, channel, stator, set of vanes and/or the like.

The housing **4110** directs the inlet gas G_{in} to flow within the flow path **4134** toward a first mixing location L_1. The inlet gas G_{in} is first mixed with the atomized flow of solution S_1 produced by the first atomizer **4200**. A first mixture of the gas G_{in} and the atomized portion of the solution S_1 is produced (identified as G_1 in FIG. **4**), having a humidity ratio ω_1, that is greater than the humidity ratio ω_{in}, and having the first axial and rotational direction A_1. The first atomizer **4200** is disposed in the housing **4110** such that the atomized portion of the solution S_1 flows with a second axial and rotational direction, as indicated by the arrow A_2. More specifically, the axial component of the second axial and rotational direction A_2, is in a substantially opposite axial direction to the first axial and rotational direction A_1, but has the same rotational direction. Similarly stated, the flow of S_1 and the flow of the inlet gas in the flow path **4134** are in an opposite axial direction at a first mixing location L_1, but are characterized by a substantially similar rotational direction.

The housing **4110** directs the flow path **4134** with the first axial and rotational direction A_1 through a first channel **4151** defined by the housing **4110**, as shown in FIG. **4**, toward a second mixing location L_2, where the gas G_1 mixes with the atomized flow of solution S_2 produced by the second atomizer **4200**. The housing **4110** is configured such that the flow of gas G_1 flowing towards the second mixing location L_2 is characterized by the second axial flow direction and the rotational flow direction, collectively indicated by arrow A_2. Thus, the axial flow direction of the gas flow at the second mixing location L_2 is substantially opposite the axial flow direction of the gas flow at the first mixing location L_1. A second mixture of the gas G_1 and the atomized portion of the solution S_2 is produced (identified as G_2 in FIG. **4**) at the second mixing location L_2, having a humidity ratio ω_2, that is greater than the humidity ratio ω_1, and having an axial and rotational direction A_2. The second atomizer **4200** is disposed in the housing **4110** such that the atomized portion of the solution S_2 flows with the first axial and rotational direction A_1. Thus, the axial velocity component of the gas flow at the second mixing location L_2 is substantially opposite the axial velocity component of the solution S_2, and the rotational velocity component of the gas flow at the second mixing location L_2 is substantially the same as the rotational velocity component of the solution S_2.

The housing **4110** directs the flow path **4134** with the second axial and rotational direction A_2 through a second channel **4152** defined by the housing **4110** toward a third mixing location L_3, where the gas G_2 mixes with the atomized flow of solution S_3 produced by the third atomizer **4200**. The housing **4110** is configured such that the flow of the gas G_2 flowing towards the third mixing location L_3 is characterized by the first axial flow direction and the rotational direction, collectively indicated by arrow A_1. Thus, the axial flow direction of the gas flow at the third mixing location L_3 is substantially opposite the axial flow direction of the gas flow at the second mixing location L_2 and substantially similar to the axial flow direction of the gas flow at the first mixing location L_1. A third mixture of the gas G_2 and the atomized portion of the solution S_3 is produced (identified as G_3 in FIG. **4**) at the third mixing location L_3, having a humidity ratio ω_3 that is greater than the humidity ratio ω_2, and having an axial and rotational direction A_1. The third atomizer **4200** is disposed in the housing **4110** such that the atomized portion of the solution S_3 flows with the second axial and rotational direction A_2. Thus, the axial velocity component of the gas flow at the third mixing location L_3 is substantially opposite the axial velocity component of the solution S_3, and the rotational velocity component of the gas flow at the third mixing location L_3 is substantially the same as the rotational velocity component of the solution S_3. Said a different way, the atomizers **4200** are positioned in the housing **4110** such that the flow of the atomized portion of the solution S_{in} is in an opposite axial direction of the flow path **4134** at each mixing location, L_1, L_2, L_3 respectively. Having mixed with the flow of the gas G_{in}, the mixture sequentially flows through the channels **4151** and **4152**, respectively, to the next mixing location. The third mixture G_3 flows through a third channel **4153** toward the outlet portion **4135** of the housing **4110** as described below.

The separator **4300** is fluidically coupled to the outlet portion **4135** of the housing **4110** such that the separator **4300** receives the mixture of the gas and solution from the outlet portion **4135** as indicated in FIG. **4** by arrow XX. The separator **4300**, which has a first outlet portion **4331**, is configured to produce a first outlet flow and a second outlet flow. More particularly, the first outlet flow includes a portion of the gas G_{in} and a vaporized portion VAP of the solvent. The second outlet flow includes a liquid portion LIQ of the solvent and the solute WASTE (i.e., solid waste) from the solution. As shown in FIG. **4**, the first outlet flow, including a portion of the gas G_{in} and the vaporized portion VAP of the solvent, can be conveyed, via the first outlet potion, to any suitable condenser (not shown in FIG. **4**) as shown by the arrow YY. The second outlet flow, including the liquid portion LIQ of the solvent and the solute WASTE, can be conveyed, via the second outlet portion **4332**, to a volume substantially outside the system, as indicated by arrow ZZ. In this manner, the separator **4300** separates the solute from the solution. Similarly stated, in embodiments in which the solution is seawater, the separator **4300** separates the salt and/or total dissolved solids from the water, thereby producing a substantially purified water vapor. The separator **4300** can use any suitable mechanism for separating the solute from the solution, such as a tortuous path, a filter, a rotating member, an electrically charged member and/or the like.

FIG. **5** is a schematic illustration of a water desalinization system **5000** according to an embodiment. The water desalinization system **5000** includes a processor **5100**, a gas processing system **5500**, and a water inlet system **5600**. The system **5000** is configured to receive an inlet flow of water containing a solute and produce a flow of water substantially free of the solute as described herein. In particular, an inlet solution S_{in} and an inlet air G_{in} are mixed by a processor **5100** to form a mixture of air, water vapor and concentrated brine solution (identified as G_1 in FIG. **5**). The mixture G_1 is then separated by the separator **5300** to produce a gaseous flow of water vapor VAP (i.e., substantially saturated air) and a flow of waste products WASTE. The water vapor VAP is conveyed to a condenser (not shown in FIG. **5**) to produce a flow of water substantially free of the solute. The waste product WASTE (e.g., the brine) is discharged in near solid form for disposal.

The water inlet system **5600**, of FIG. **5**, includes a water supply member **5650**, containing a solution S_{in}. The water supply member **5650** can be of any suitable shape and/or size, and can be constructed from any suitable material. In some embodiments, the water supply member **5650** can be constructed from any applicable plastic, composite, metal, glass, and/or the like, configured to store the solution S_{in}. Furthermore, the water supply system **5650** can have a fixed inlet portion with any appropriate coupling system and/or a removable fill system such as a screw on lid, plug, and/or cap to receive the solution. The solution S_{in} can be any suitable solution of a solvent containing a solute. In some embodiments, for example, the solution can be a solution of water (the solvent) and salt, dissolved solids or the like (the solute). Similarly stated, in some embodiments, the solution can be seawater, brackish water or the like.

The water supply member **5650** is fluidically coupled to an inlet portion **5210** of the atomizer **5200**. The inlet flow of solution S_{in} can be conveyed to the atomizer **5200** (as indicated by arrow BBB in FIG. **5**) via any suitable mechanism, such as for example, by a series of supply lines (each of which corresponds to one of the atomizers **2200**), an inlet manifold, or the like. More particularly, the inlet flow of the solution S_{in} can be delivered using a gravity fed method, a pump, a suction system or any other suitable method. In some embodiments, the supply lines can be configured to interact with other subsystems to produce desired properties. For example, in some embodiments the supply lines can interact with a condenser (not shown in FIG. **5**) to increase the temperature of the inlet solution S_{in}, similar to the arrangement shown and described above with reference to FIG. **1**.

The air processing system **5500** includes an air source **5510** configured to receive an inlet flow of gas Gin and deliver a first portion of the inlet gas G_{atom} to the inlet portion **5210** of the atomizer **5200** and a second portion gas G_{vap-in} to an inlet portion **5122** of the processor **5100**. The gas G_{atom} can be conveyed to the atomizer **5200** (as shown by arrow CCC in FIG. **5**) via any suitable mechanism, such as for example, a plenum, a pipe, an inlet manifold, or the like. Similarly, the gas G_{vap-in} can be conveyed to the processor **5100** (as shown by arrow DDD in FIG. **5**) via any suitable mechanism, such as for example, a plenum, a pipe, an inlet manifold, or the like. In particular, the gas processor system **5500** delivers the gas G_{atom} and the gas G_{vap-in} to the atomizer **5200** and the processor **5100** in parallel. Similarly stated, the flow paths of the gas G_{atom} and the gas G_{vap-in} can be delivered to the respective inlets simultaneously and/or the process of delivery occurs concurrently. The gas source **5510** can be any suitable gas source (e.g., a Rotex C30-74 supercharger) and can produce any suitable pressure (e.g., 3 p.s.i. to 10 p.s.i.).

The processor **5100** includes the housing **5110** with the inlet portion **5122** and an outlet portion **5135**, the atomizer **5200** with the inlet portion **5210** and an outlet portion **5240**, and a separator **5300**. The inlet portion **5210** of the atomizer **5200** is configured to receive the inlet flow of solution S_{in}, and the gas G_{atom}, as described above. The outlet portion **5240** of each atomizer **5200** is configured to produce an atomized flow of the solution S_{in}. Similarly stated, the atomizer **5200** and/or the outlet portion **5240** is configured to produce a spray including small particles of the solution S_{in}. More particularly, the atomizer **5200** is a "gas-assisted" atomizer that mixes the inlet flow of the solution S_{in} with the gas flow G_{atom} to facilitate the atomization process. The atomized portion of the solution S_{in} produced by the outlet portion **5240** of the first atomizer **5200** is identified as S_1. Although FIG. **5** is shown as having one atomizer **5200**, in other embodiments, the processor system **5100** can have any suitable number of atomizers **5200**.

The housing **5110** includes the inlet portion **5122**, that receives a gas $G_{vap\text{-}in}$, (which has an initial humidity ratio ω_{in}) and an outlet portion **5135**. The housing **5110** defines a flow path **5134** between the inlet portion **5122** and the outlet portion **5135**. As shown in FIG. **5**, the atomizer **5200** is disposed, at least partially, within the housing **5110** such that the outlet portion **5240** of the atomizer **5200** is in fluid communication with the flow path **5134**. This arrangement permits the gas $G_{vap\text{-}in}$, flowing within the flow path **5134**, to be mixed with the atomized flow of the solution S_{in} produced by the atomizer **5200**. More particularly, the housing **5110** receives an inlet gas $G_{vap\text{-}in}$, having an initial humidity ratio of ω_{in} via the inlet portion **5122**, as indicated by arrow AAA. The inlet gas $G_{vap\text{-}in}$ flows within the flow path **5134** and is mixed with the atomized flow of solution S_1 produced by the atomizer **5200** to produce a mixture of the gas $G_{vap\text{-}in}$ and the atomized portion of the solution S_1 (identified as G_1 in FIG. **5**) having a humidity ratio ω_1 that is greater than the humidity ratio ω_{in}. Although FIG. **5** is shown as having one atomizer **5200**, in other embodiments, the processor system **5100** can have any suitable number of atomizers **5200**. In this instance, the housing **5110** and the atomizers **5200** can be collectively configured to sequentially mix the inlet gas G_{in} with atomized flow produced by each atomizer **5200** in series (i.e., at a different time and/or a different spatial location within the flow path **5134**) such that the humidity ratio ω increases as the gas solution mixture flows past each successive atomizer **5200**. In this manner, the inlet solution S_{in} can be mixed with and/or atomized into the inlet gas G_{in} flow to produce a mixture having a desired humidity ratio that is subsequently conveyed into the separator **5300**, as described below.

The separator **5300** is fluidically coupled to the outlet portion **5135** of the housing **5110** such that the separator **5300** receives the mixture of the gas and solution from the outlet portion **5135** as indicated in FIG. **5** by arrow EEE. The separator **5300**, which has a first outlet portion **5331** and a second outlet portion **5332**, is configured to produce a first outlet flow and a second outlet flow. More particularly, the first outlet flow includes a portion of the gas G_{in} and a vaporized portion VAP of the solvent. The second outlet flow includes a liquid portion LIQ of the solvent and the solute WASTE (i.e., the solid waste) from the solution. As shown in FIG. **5**, the first outlet flow, including a portion of the gas G_{in} and the vaporized portion VAP of the solvent, can be conveyed, via the first outlet portion **5331**, to any suitable condenser (not shown in FIG. **5**) as shown by the arrow FFF. The second outlet flow, including the liquid portion LIQ of the solvent and the solute WASTE, can be conveyed, via the second outlet portion **5332**, to a volume substantially outside the system, as indicated by arrow GGG. In this manner, the separator **5300** separates the solute from the solution. Similarly stated, in embodiments in which the solution is seawater, the separator **5300** separates the salt and/or total dissolved solids from the water, thereby producing a substantially purified water vapor. The separator **5300** can use any suitable mechanism for separating the solute from the solution, such as a tortuous path, a filter, a rotating member, an electrically charged member and/or the like.

FIGS. **6-9** are views of a water desalinization system **6000** according to an embodiment. FIGS. **6** and **7** are a right side view and a left side view, respectively, of the water desalinization system **6000** that includes a processor **6100**, a separator **6300**, a condenser assembly (not shown in FIGS. **6** through **9**), an air processing subsystem **6500**, a water inlet assembly **6600**, and a control assembly (not shown in FIGS. **6** through **9**). As described in more detail herein, the system **6000** is configured to receive an inlet flow of a solution containing a solute (e.g., seawater) and produce a flow of water substantially free of the solute (e.g., desalinated water, or water that is free of dissolved solids). In particular, inlet seawater and inlet air are mixed by the processor **6100** to form a mixture of air, water vapor and concentrated brine solution. The mixture is then conveyed to the separator **6300** to produce a gaseous flow of water vapor (i.e., substantially saturated air) and a flow of waste products, including the solute, dissolved solids, and/or brine. The water vapor is condensed within the condenser assembly (not shown in FIGS. **6** through **9**) to produce a flow of water substantially free of the solute desalinated water. The waste products (e.g., the brine) is discharged in near solid form for disposal.

The desalinization system **6000** is coupled to a frame **6001** (FIG. **8**) configured to provide support to the system **6000**. The frame **6001**, as shown in FIGS. **8** and **9**, encloses, at least partially, a motor (not shown) such that a drive shaft **6002** extends from the rear of the frame **6001**. The drive shaft **6002** is coupled to a pulley configured to form a belt drive for an air pump **6510**, as shown in FIG. **9**. Certain components of the desalinization system **6000**, such as, for example, the housing **6540**, are not shown in FIG. **9** to more clearly show the components of the frame **6001** and/or the mounting assembly of the system. The frame **6001** can contain various protrusions, tensioners, extrusions, and/or bolt-on components, which are not described in detail herein, to facilitate the interaction and/or interconnection of the components of the desalinization system **6000** as described herein. Furthermore, any existing shape, size, form, material, and/or the like can be modified to tune the system. The use of the word "tune" used herein relates to the changing of system parameters such that a desired effect is achieved in the functioning, appearance, weight, efficiency, and/or the like. For example, the shape, size, and position of the tensioner can be modified, resulting in overall weight reduction of the system, thereby increasing portability.

The air processing subsystem **6500** is configured to circulate air within the water desalinization system **6000**. The air processing subsystem **6500** includes the air pump **6510** and a housing **6540**. The housing **6540** includes a back section **6541** and a front section **6542**, and encases, at least partially, the air pump **6510**, as shown in FIGS. **11** and **12**. The front section **6542** of the housing **6540** includes an inlet portion **6545** and an outlet portion **6546**. The motor used to drive the air pump **6510** can be any suitable motor. For example, the motor can be various sizes with differing power outputs.

The air pump **6510**, as shown in FIGS. **11** and **13**, includes an inlet portion **6511** and an outlet portion **6514**, and is coupled within the back section **6541** and front section **6542** of the housing **6540**. The air pump **6510** can be any suitable air pump that produces the desired pressure and flow for the desalinization system **6000**. In some embodiments, the air pump **6510** is a Rotex C30-74 supercharger that is driven by the motor, as mentioned above. Furthermore, the air pump

6510 can produce a flow rate between 30 cubic feet per minute and 3000 cubic feet per minute and a pressure between 3 p.s.i. and 10 p.s.i.

More particularly, the air pump **6510** is mechanically fastened (e.g., using bolting hardware) to the housing **6540**. An O-ring **6544** is used to form an airtight seal between the inlet portion **6511** of the air pump **6510** and the front side **6542** of the housing **6540**. Similarly, the housing **6540**, is coupled to the processor **6100** using mechanical fasteners and an O-ring **6543** is used to form an air-tight seal between the air processing subsystem **6500** and the processor **6100**, as shown in FIG. **11**. The air processing subsystem **6500** is coupled to the processor **6100** such that the inlet portion **6545** of the housing **6540** is adjacent to an inlet portion **6111** of the processor **6100**. As described in more detail below, the processor **6100** includes a housing **6110** that defines a set of inlet openings **6112**. The air pump **6510** is configured to draw a portion of air G_{in}, shown in FIG. **13**, through the set of openings **6112** and convey the air G_{in} to portions of the processor **6100**, as described in detail herein.

The processor **6100** includes the housing **6110**, a series of atomizers **6200** (also referred to as atomizer assemblies) and a series of vaporizers **6270**, as shown in FIG. **14**. The housing **6110** includes a first portion **6120**, a second portion **6130**, and a bulkhead **6140** disposed between the first portion **6120** and the second portion **6130**. As shown in FIGS. **14** and **15**, the first portion **6120** defines an interior volume **6121** between an exterior wall **6123** and the bulkhead **6140**. Additionally, the exterior wall **6123** and the bulkhead **6140** collectively form an inlet portion **6122** to which the outlet portion **6546** of the air processor subsystem **6500** is coupled. The first portion **6120** of the processor **6100** is configured to house, at least partially within the interior volume **6121**, the series of atomizers **6200**. In particular, as shown in FIG. **18**, the bulkhead **6140** defines a set of openings **6142** within which the nozzle portion **6240** of each atomizers **6200** is mounted. Although shown in FIGS. **14** and **15** as including eight atomizers **6200**, in other embodiments the processor **6100** can include more or less than eight atomizers **6200**.

The second portion **6130** of the processor **6100** includes a series of interior walls **6131** (see FIGS. **19-22**) and a cover **6137**, as shown in FIGS. **14** and **15**. As shown in FIGS. **21** and **22**, the second portion **6130** further defines an inlet opening **6136** and an outlet opening **6135**. The second portion **6130** of the processor **6100** is configured to house at least a portion of the atomizers **6200** (e.g., the nozzle portion **6240**) and the vaporizers **6270**. More particularly, the interior walls **6131** define a first interior volume **6132** around the inlet portion **6272** of the vaporizers **6270** (see FIG. **20**, which shows the second portion **6130** when viewed from the right side of the desalinization system **6000**) and a second interior volume **6133** around the outlet portion **6282** of the vaporizers **6270** (see FIG. **21**, which shows the second portion **6130** when viewed from the left side of the desalinization system **6000**). The interior walls **6131** define a flow path **6134** between the inlet opening **6136** of the second portion **6130**, where the air G_{vap-in} enters the second portion **6130** of the processor **6100**, and the outlet opening **6135** of the second portion **6130**, where the air $G_{vap-out}$ exits the second portion **6130** of the processor **6100** and enters the separator **6300**.

In use, the inlet air G_{in} enters the air blower **6510** and, upon exiting the air blower **6510**, enters the first portion **6120** of the processor **6100** through the inlet opening **6122** (FIG. **15**). The air G_{in} can be delivered to the first portion **6120** at any suitable pressure, such as, for example, within the range of 3 p.s.i. and 10 p.s.i., and any suitable flow rate, such as, for example, within the range of 30 cubic feet per minute and 3000 cubic feet per minute. When the inlet air G_{in} enters the inlet opening **6122** a first portion of the air G_{atom} (see e.g., FIG. **16**) flows within the interior volume **6121** defined by the first portion **6120** of the processor **6100**. A second portion of the air G_{vap-in} enters the second portion **6130** of the processor through a flow opening **6141** in the bulkhead **6140**, as shown in FIG. **17**. In this manner, the inlet air G_{in} flows in parallel to the atomizers **6200** and the vaporizers **6270**.

The characteristics (i.e., flow rate, pressure, volume, etc.) of the portion of the flow of air G_{atom} within the first portion **6120** and the flow of air G_{vap-in} within the second portion **6130** can be controlled by modifying the flow opening **6141** in the bulkhead **6140**. For example, FIG. **18** shows the bulkhead **6140** defining a flow opening **6141** the is substantially oblong. Similarly stated, the flow opening **6141** is configured to be a slot in the bulkhead **6140**, thereby allowing more air G_{vap-in} to flow into the second portion **6130** of the processor **6100**. Furthermore, the flow characteristics can be modified by the edges and/or contour of the flow opening **6141**. For example, the edges and/or contour defined by flow opening **6141** can be rounded or beveled as shown in FIG. **17**, thus producing a more laminar or uniform flow through the flow opening **6141**. As shown in FIG. **18**, the edges and/or contour defined by the flow opening **6141** can be substantially non-rounded producing a more turbulent flow through the flow opening **6141**.

As shown in FIG. **22**, the interior walls **6131** of the second portion **6130** define the flow path **6134** such that air G_{vap-in} flows from the inlet opening **6136** to the inlet portion **6272** of the first vaporizer **6270**. The air G_{vap-in} then flows within the flow path **6134** through the first vaporizer **6270** and exits via the outlet portion **6282** of the first vaporizer **6270**. As described in more detail below, the vaporizer **6270** receives the inlet air G_{vap-in}, having an initial humidity ratio of ω_{in} via the inlet portion **6272**. The inlet gas G_{vap-in} is mixed with the atomized solution S_1 produced by the first atomizer **6200** to produce a mixture G_1 of the gas G_{vap-in} and the atomized solution S_1, having a humidity ratio ω_1 that is greater than the initial humidity ratio ω_{in}. Thus, as the air travels through the vaporizers, the humidity ratio of the air (i.e., the amount of water content in the air) is sequentially increased. The interior walls **6131** are configured such that the gas then flows within the flow path **6134** to the inlet portion **6272** of the next vaporizer **6270**. The interior walls **6131** are configured such that the gas flows within the flow path **6134** through the second portion **6130** of the processor **6100** until reaching the outlet opening **6135**, as shown in FIG. **22**. The characteristics of the fluid within the flow path **6134** and the processes performed on the fluid are described in more detail herein.

Each atomizer **6200** includes the injector portion **6210** and the nozzle portion **6240**, as mentioned above. As shown in FIGS. **24**, **25** and **29**, the injector portion **6210** includes a first end portion **6211** and a second end portion **6212**. The first end portion **6211** is configured to extend through and/or be accessible through the exterior wall **6123** of the housing **6110** (best shown in FIG. **15**) to couple a supply line **6640** to the injector portion **6210** via the inlet line coupling **6216**. The first end portion **6211** includes an outer surface **6213** that defines a sealing groove **6215**. A sealing member **6214** (e.g., an O-ring) is configured to fit into the sealing groove **6215** to produce a substantially fluid-tight and/or hermetic seal with the exterior wall **6123** of the housing **6110**. The injector portion **6210** of each atomizer **6200** is configured to receive the inlet flow of the solution S_{in} via the supply line **6640**, as mentioned above. The inlet flow of solution S_{in} can be conveyed to the atomizers **6200** via any suitable mechanism, such as, for example, the methods described above in the water desalinization system

1000. The solution S_{in} can be any suitable solution of a solvent containing a solute. For example, the solution can be a solution of water (the solvent) and salt, dissolved solids or the like (the solute). Similarly stated, in some embodiments, the solution can be seawater, brackish water or the like.

The second end portion **6212** of the injector portion **6210** is configured to receive and be coupled to an injector insert **6219**. More particularly, the injector insert **6219** is disposed within the second end portion **6212** using a threaded coupling. The outer surface **6213** at the second end portion **6212** defines a set of helical grooves **6221**, as shown in FIGS. **24** and **25**. The helical grooves **6221** are configured to produce a rotational velocity component when the air G_{atom} flows into the atomizer **6200**, as described in more detail herein. The injector portion **6210** is disposed within the first portion **6120** of the housing **6110** such that the second end portion **6212** of the injector **6210** is spaced apart from a first end portion **6241** of the nozzle **6240** by a distance D. The distance D produces a first mixing volume **6225**, as shown in FIG. **29**, within which the inlet air G_{atom} aids in the atomization of the solution S_{in}, as described herein. Expanding further, the distance D can be increased by modifying the placement of the injector **6210** in the housing **6110**. Therefore, the concentration of the atomized solution S_{in} per volume of the air G_{atom} that enters the nozzle **6240** can be adjusted by adjusting the distance D between the injector **6210** and the nozzle **6240**. For example, the distance D can be increased such that a lower concentration of the solution S_{in} per volume of the air G_{atom} enters the nozzle **6240**.

The injector insert **6219** defines an end surface **6224** with a solution outlet orifice **6218** substantially in the center. The end surface **6224** is substantially flat and the solution outlet orifice **6218** is an extrusion (i.e., removal of material). The shape of the solution outlet orifice **6218** can be any suitable shape such that the solution outlet orifice **6218** can reduce the solution S_{in} into an atomized flow (i.e., very small particles of the solution S_{in}).

The nozzle portion **6240** includes a first end portion **6241** and a second end portion **6242**, as shown in FIGS. **25** and **29**. The first end portion **6241** includes an end surface **6249** defining an opening configured to receive the atomized portion of the solution S_{in}. An outer surface **6243** of the first end portion **6241** of the nozzle portion **6240** defines a set of helical grooves **6244**, as shown in FIGS. **24** and **25**. The flow of the air G_{atom} is configured to flow within the helical grooves **6244** and into the first mixing volume **6225** such that the helical grooves **6244** impart a rotational velocity component in the flow, as described in more detail herein. The outer surface **6243** also includes a mounting surface **6247** that protrudes from the outer surface **6243** (FIG. **25**). The mounting surface **6247** provides a discontinuity in the outer surface **6247** that defines, along with the second end portion **6242**, a length L that the second end portion **6242** of the nozzle **6240** protrudes into the vaporizer **6270**. Furthermore, the mounting surface **6247** (i.e., the larger diameter) is configured to the fit within the mounting openings **6142** of the bulkhead **6140**, as best shown in FIG. **18**.

The second end portion **6242** of the nozzle portion **6240** includes an outer surface **6250** and an internal surface **6251**. As described in more detail herein, the inner surface **6251** defines a flow path **6252** through which the atomized solution S_1 flow from the first mixing volume **6225** to the vaporizer **6270**. Although the internal surface **6251** is shown as being tapered such that the nozzle portion **6240** acts as a diverging nozzle (i.e., a nozzle having an increased flow area), in other embodiments, the internal surface **6251** can have any suitable geometry.

The vaporizer **6270** includes the inlet portion **6272** and the outlet portion **6282**. The outlet portion **6282** is configured to receive a portion of the nozzle **6240** of the atomizer **6200**, as shown in FIGS. **25**, **26** and **29**, and described above. As shown in FIG. **29**, a portion of the nozzle **6240** of the atomizer **6200** is disposed at least within the outlet portion **6282** such that the outer surface **6250** of the second end portion **6242** of the nozzle **6240** and the inner surface **6277** of the outlet portion define a flow path **6278**. The outlet portion **6282** defines a set of outlet openings **6286** through which the flow exits the vaporizer **6270**. The outlet openings **6286**, as shown in FIG. **25**, are substantially oblong openings, though in other embodiments, the openings can be any shape and or configuration. For example, the outlet openings **6286** could be in a helical configuration, similar to the inlet openings **6276** described below.

The inlet portion **6272** defines a set of inlet openings **6276** that are configured to receive a flow of inlet gas $G_{vap\text{-}in}$ therethrough. The helical shape of the inlet openings **6276** is configured to produce a rotational flow through the body of the vaporizer **6270**. Moreover, the inlet portion **6272** and the second end portion **6242** of the nozzle **6240** define a second mixing volume **6279** (FIG. **29**) within which the inlet gas $G_{vap\text{-}in}$ is mixed with the atomized solution S_1 from the first mixing volume **6225**. The size, length and/or volume of the second mixing volume **6279** is inversely proportional to the length L of the nozzle **6240** protruding into the vaporizer **6270**. For example, reducing the distance that the mounting surface **6247** extends from the first end portion **6241** increases the length L of the nozzle **6240** protruding into the vaporizer **6270**, thus reducing the size of the second mixing volume **6279**.

FIG. **29** is a cross-sectional view of the atomizer **6200** and the vaporizer **6270**, and shows the flow of the solution S_{in}, the flow of the air G_{atom}, and the flow of the air $G_{vap\text{-}in}$. As mentioned above, the supply line **6640** is coupled to the injector portion **6210** of the atomizer. The solution S_{in} flows within a liquid flow path **6217** in the supply line **6640** and enters the injector portion **6210** via the inlet line coupling **6216**. The solution S_{in} flows within the liquid flow path **6217** and enters the injector insert **6219** where the solution outlet orifice **6218** receives the solution S_{in} and at least partially atomizes the flow as the solution S_{in} exits the injector portion **6210** and enters the first mixing volume **6225**. The solution outlet orifice **6218** can define any suitable shape such that the flow of the solution S_{in} is atomized upon exiting. For example, in some embodiments the solution outlet orifice **6218** could create a conical spray of the atomized portion of the solution S_1, while in other embodiments, the atomized flow of the solution S_1 can be fanned (i.e., a substantially flat and wide flow).

As described above, a portion of the inlet airflow G_{atom} flows within the helical grooves **6244** and into the first mixing volume **6225** such that the helical grooves **6244** impart a rotational velocity component in the flow, as indicated by arrow R_1. The air G_{atom} mixes with the atomized portion of the solution S_1 in the first mixing volume **6225**, such that the air G_{atom} suspends and/or further atomizes the solution S_1. Similarly stated, the portion of the solution S_1 is reduced to small droplets, a fine spray and/or vapor, and is suspended in the air G_{atom}. By mixing the solution S_1 with the air G_{atom}, the surface area to volume ratio of the solution S_1 is increased aiding in mixing and eventual evaporation, as described herein. Expanding further, the rotation of the injector portion **6210** and the nozzle portion **6240** produces a rotational component in the flow of the solution S_{in} and the atomized flow of the solution S_1. The rotation of the solution insures a more complete mixture with the air G_{atom}, described above, and the air G_{vap-in}, as described below.

In this manner, the atomizer **6200** produces a spray including small particles of the solution S_{in}. In particular, the atomized portion of the solution S_{in} produced by the solution outlet orifice **6218** of the first atomizer **6200** is identified as S_1. Similarly, the atomized portion of the solution S_{in} produced by the solution outlet orifice **6218** of the second atomizer **6200** is identified as S_2, and so on throughout the housing **6110** including all the atomizers **6200** of the water desalinization system **6000**.

The atomized portion of the solution S_1 enters the nozzle portion **6240** via the inlet portion **6241**. The atomized solution S_1 flows within the flow path **6252** defined by the internal surface **6251** of the nozzle portion **6240** with a given axial and rotational velocity. As described above, the tapered portion **6253** allows the atomized solution S_1 to expand within the interior surface **6251** and thus increases the surface area of the flow path **6252**. The increase in surface area of the flow path **6252** can allow for a more complete mixing with the air G_{vap-in}. The air G_{vap-in} enters the vaporizer **6270** through the inlet openings **6276** of the inlet portion **6273**. The flow of the atomized solution S_1 exits the nozzle portion **6240** at the second end portion **6242** and mixes with the flow of the air G_{vap-in} in the second mixing volume **6279**.

As shown in FIG. **29**, the vaporizer **6270** receives the inlet air G_{vap-in}, having an initial humidity ratio of ω_{in} via the inlet portion **6273**. The inlet gas G_{vap-in} is mixed with the atomized solution S_1 within the second mixing volume **6279** and/or the flow path **6278** to produce a mixture G_1 of the gas G_{vap-in} and the atomized solution S_1. The mixture G_1 has a humidity ratio ω_1 that is greater than the initial humidity ratio ω_{in}. The mixture G_1 flows within the flow path **6278** defined by the inner surface **6277** of the vaporizer **6270** and the outer surface **6250** of the nozzle portion **6240**. The mixture exits the vaporizer **6270** through the outlet openings **6286** and is conveyed within the flow path **6134** defined by the interior walls **6131** of the housing **6110** to the inlet portion of the next vaporizer in the series.

FIG. **23** shows the second portion **6130** of the processor **6100** including arrows to illustrate the serial flow through each of the vaporizers **6270**. As described above, the mixture G_1, having a humidity ratio of ω_1, exits the vaporizer **6270** and enters the flow path **6134** defined by the interior walls **6131** of the housing **6110**. The interior walls **6131** of the housing **6110** direct the flow to the second vaporizer and/or the outlet of the second atomizer **6200**. More particularly, the shape and configuration of the interior walls **6131** of the housing **6110** define the flow path **6134** from the outlet portion **6282** of a specific vaporizer **6270** to the inlet portion (not shown in FIG. **23**) of the successive vaporizer **6270**. As described above for the first atomizer **6200**, the second atomizer **6200** receives the solution S_{in} and produces the atomized flow S_2. The interior walls **6131** of the housing **6110** direct the flow path **6134** of the mixture G_1 flows within the flow path **6134** to the second vaporizer **6270** via the inlet portion **6273**. The solution S_2 is then mixed with the flow of the mixture G_1 within the second vaporizer **6270** producing a second mixture G_2 and having a humidity ratio ω_2 that is greater than the humidity ratio ω_1. Said a different way, the housing **6110**, the atomizers **6200** and the vaporizers **6270** are collectively configured to sequentially mix the inlet gas G_{vap-in} with atomized flow produced by each atomizer **6200** in series (i.e., at a different time and/or a different spatial location within the flow path **6134**) such that the humidity ratio ω increases as the air solution mixture flows past the outlet of each successive atomizer **6200**. In this manner, the inlet solution S_{in} is mixed with and/or atomized into the inlet gas G_{vap-in} flow to produce a mixture having a desired humidity ratio that is subsequently conveyed, via the outlet opening **6135** (FIG. **23**), to the separator **6300**, as described below.

FIGS. **31-35** show the separator **6300**, which includes a housing **6310**, a first separator member **6325** and a second separator member **6330** (see e.g., FIGS. **34** and **35**), a waste outlet tube **6350**, and a coupling member **6318**. The separator **6300** is coupled to the housing **6110** of the processor **6100** such that an inlet opening **6313** receives a mixture G_8 (i.e., the mixture of the air G_{vap-in} and the solution S_{in} after exiting the eighth atomizer) from the outlet opening **6135** of the housing **6110** (shown in FIG. **35**). More specifically, the separator **6300** includes a top flange member **6319** configured to be coupled in fluid communication with the outlet opening **6135** of the housing **6110**. The top flange member **6319** includes a sealing groove **6320** that is configured to encircle the inlet opening **6313**. A sealing member **6321** is configured to fit in the sealing groove **6320** and produce a substantially airtight seal when the separator **6300** is coupled to the processor **6100**.

The housing **6310** includes a first section **6317**, a second section **6312**, and a spacer member **6322** that, when coupled together, collectively define an internal volume within which the first separator member **6325** and the second separator member **6330** are disposed, as shown in FIG. **35**. As shown in FIG. **33**, the first section **6317** of the housing **6310** defines a vapor opening **6315** and a waste outlet opening **6314**. As described herein, the first section **6317** is configured such that a first outlet flow (i.e., the vapor) can flow from the separator **6300** to a first volume substantially outside of the separator **6300** via the vapor opening **6315**. The first section **6317** is configured such that a second outlet flow (i.e., the waste) can flow from the separator **6300** to a second volume substantially outside of the separator **6300** via the waste outlet opening **6314**.

The first section **6315** further includes an interior wall **6311** that is tapered. Similarly stated, an area defined by the interior wall **6311** of the first section **6315** increases along an axis of the first section **6315**. In this manner, the volume **6337** between the second separator member **6330** and the interior walls **6311** is reduced. This arrangement enhances the effectiveness of the second separator member **6330**, as further described herein.

The first separator member **6325** includes an outer surface **6327** that includes a collector flange **6328**, extending radially from the outer surface **6327**, and defines a set of openings **6326**. The set of openings **6326** are substantially oblong and are disposed on the first separator member **6325** at the base of the collector flange **6328**, as shown in FIGS. **31** and **34**. This arrangement produces a rotational motion of the mixture flowing through the openings, which results in the movement of the vaporized portion VAP of the solvent within the flow path **6341**, as described below with reference to FIG. **35**. Similarly stated, the outer surface **6327** of the first separator member **6325** is configured to impart and/or redirect a tangential velocity on the flow as it passes through the openings **6326**. Although shown in FIG. **34** as substantially oblong, in some embodiments, the set of openings **6326** can be any suitable shape or size, for example, the set of openings **6326** can be round, square, rectangular, and/or a combination of any shapes and/or sizes. Furthermore, the set of openings **6326** can be disposed asymmetrically (e.g., unevenly spaced) along the outer surface **6327**.

As described above, the collector flange **6328** extends radially from the first separator member **6325**. When in use, the back of the collector flange **6328** mates to a mounting surface

6316 of the second section **6312** and a flange opening defined by the spacer member **6322** fits around the collector flange **6328**. Therefore, when the first section **6317** and the second section **6312** are coupled, the spacer member **6322** provides a desired distance between the first section **6317** and the second section **6312** in which the collector flange **6328** is disposed, as implied in the exploded view FIG. **31**.

The second separator member **6330** includes a first end portion **6331**, a second end portion **6332**, an outer surface **6334** that includes a set of grooves **6335**, and an inner surface **6340**, that defines a flow path **6341**. The first end portion **6331** of the second separator member **6330** is configured to be disposed, at least partially, within the first separator member **6325**. The outer surface **6334** that is tapered and configured to transition from a larger diameter of the first end portion **6331** to a smaller diameter of the second end portion **6332**, as shown in FIG. **34**. The tapered outer surface **6334** and the tapered interior walls **6311**, described above, define a volume **6337**. When in use, the interior walls **6311** and the outer surface **6334** compress the mixture G_8 such that a portion of the mixture G_8 is collected by the series of grooves **6335** as described herein. The portion of the mixture G_8 that is not collected by the series of grooves **6335** flows within the flow path **6341** and exits the separator through the vapor opening **6315**.

FIG. **35** is a cross-sectional view of the separator **6300** that shows the flow of the mixture G_8 through the separator **6300**. The mixture G_8 includes a portion of the air G_{vap-in}, a vaporized portion VAP of the solvent, a liquid portion LIQ of the solvent, and a solute WASTE (i.e., the solid waste) from the solution (e.g., the solution S_{in}). As the flow of the mixture G_8 contacts the outer surface **6327** of the first separator member **6325**, a first portion of the mixture G_8 enters the set of openings **6326** (FIG. **28**). A second portion of the mixture G_8 contacts the outer surface **6327** of the first separator member **6325** and continues to flow along the circumference of the first separator member **6325**. More specifically, the second portion of the mixture G_8 is largely comprised of a portion of the liquid LIQ and the solute WASTE (i.e., the solid waste). The first portion of the mixture G_8 is largely comprised of a portion of the vaporized solvent VAP and the portion of the air G_{vap-in}, with substantially less amounts of the liquid LIQ and the solute WASTE. Expanding further, the properties (i.e., density and flow characteristics) of the liquid portion LIQ and the solute WASTE lead to a higher concentration of these portions collecting on the outer surface **6327** of the first separator member **6325** than the portions of the air G_{vap-in} and the vaporized solvent VAP. Conversely, higher concentrations of the air G_{vap-in} and the vaporized solvent VAP, relative to the portions of the liquid LIQ and the solute WASTE, flow through the set of openings **6326** due to their relative low density and less constrained flow characteristics. Similarly stated, the first separator member **6325** is configured to separate a portion of the mixture G_8 into two portions; the first portion being largely comprised of the liquid LIQ and the solute WASTE and the second portion being largely comprised of a portion of the air G_{vap-in} and the vaporized solvent VAP.

As mentioned above, the interior walls **6311** of the housing **6310** and the second separator member **6330** are tapered. This arrangement aids in the flow of the first portion of the mixture G_8 and reduces the volume **6337** between the interior walls **6311** and the second separation member **6330**. As the first portion of the flow (comprised largely of the portion of the air G_{vap-in} and the vaporized solvent VAP) enters the volume **6337**, the flow is compressed, forcing the portions of the liquid LIQ and the solute WASTE toward the outer surface **6334** of the second separation member **6330**. More specifically, as the flow is compressed, the greater density of the liquid LIQ and the solute WASTE causes these portions to be disposed below the flow of the portions of the air G_{vap-in} and the vaporized solution VAP. The set of grooves **6335** are configured to collect the portions of the liquid LIQ and the solute WASTE such that these portions flow along the circumference of the outer surface **6334** and within the grooves **6335** until the bottom of the second separator member **6330**, where they drop to the inner surface **6329** of the first separation member **6325**. The liquid LIQ and the solute WASTE exit the first separation member **6325** via the set of openings **6326**. The liquid LIQ and the solute WASTE flow within the housing **6310** to the waste opening **6314** (FIG. **33**) where these portions flow, within the waste outlet tube **6350**, to a volume substantially outside of the water desalinization system **6000** for disposal. As shown in FIG. **36**, the waste outlet tube **6350** includes an waste inlet member **6355**. The waste inlet member **6355**, as shown in FIG. **37**, includes a set of helical openings **6356** configured to accept the flow of the liquid LIQ and the solute WASTE. The use of the waste inlet member **6355** reduces clogging at the waste opening **6314**. Furthermore the waste outlet tube **6350** can include an auger **6357** (see e.g., FIGS. **38** and **39**). Similar to the waste inlet member **6355**, the auger **6357** can reduce clogging within the waste outlet tube **6350** thereby, reducing the potential of downtime or mechanical failure due to clogging. Although shown as including a helical (or spiral) protrusion, the auger **6357** can be of any suitable shape and/or size.

The flow of the air G_{vap-in} and the vaporized solvent VAP, substantially free from the liquid portion LIQ and the solute WASTE, flow within a flow path **6341** and enter an interior volume defined by an inner surface **6340** of the second separator member **6330**. The inner surface **6340** is configured to taper **6342**, with a larger diameter at the inlet portion and a smaller diameter at the outlet portion. This arrangement further compresses the air G_{vap-in} and the vaporized solvent VAP and, as such, starts to condense the air G_{vap-in} and the vaporized solvent VAP. The air G_{vap-in} and the vaporized solvent VAP exit the separator **6300** at the vapor outlet **6360**. The coupling member **6318** is configured to couple to any suitable transport system configured to transport the air G_{vap-in} and the vaporized solvent VAP to a volume substantially outside the separator **6300** (not shown in FIG. **30-35**). For example, the air G_{vap-in} and the vaporized solvent VAP can be transported to a condenser as described in detail in the water desalinization system **1000** above.

While specific atomizers are described herein, the components and configurations of the atomizer can vary. For example, FIG. **40** is a schematic illustration of an atomizer assembly **7200** according to an embodiment. The atomizer includes an injector **7210** and a nozzle **7240**. The injector **7210** includes a first end portion **7211** and a second end portion **7212**, and includes a wall **7226**. The first end portion **7211** can include any suitable interface, coupling, or inlet, configured to receive a portion of a solution S_{in}. For example, the first end portion **7211** can be coupled to an inlet supply line (not shown in FIG. **40**). As described herein, the solution S_{in} can be any solution of a solvent containing a solute such as seawater, saltwater, brackish water, and/or the like.

The wall **7226** of the injector **7210** defines a flow path **7217**, such that the solution S_{in} flows within the flow path **7217** between the first end portion **7211** and the second end portion **7212**. Although shown in FIG. **40** as substantially smooth, the interior surface of the wall **7226** can include any suitable texture, groove, contour, and/or the like configured to induce a particular fluid flow characteristic. For example, the interior surface of the wall **7226** can define a series of helical grooves such as to produce a rotational component in the flow of the solution S_{in} within the flow path **7217**.

The second end portion **7212** includes an end surface **7224** that defines an outlet orifice **7218**. The end surface **7224** can be any suitable shape or configuration. For example, the end surface **7224** can be substantially flat, while in other embodiments the end surface **7224** can include a raised outer edge, such as to define a volume therein. Similarly, the end surface **7224** can include contours, ridges, grooves, and/or the like configured to induce a particular fluid flow characteristic, as further described below. The outlet orifice **7218** can be any suitable orifice configured to produce an outlet flow (e.g., spray) that includes smaller particles of the solution S_{in} than the inlet flow of the solution S_{in}. Similarly stated, the outlet orifice **7218** can be configured to produce at least a partially atomized flow of the solution S_{in}. Furthermore, the outlet orifice **7218** can be defined by the end surface **7224**, as described above, and in other embodiments, the outlet orifice **7218** can be a threaded insert configured to couple to the injector **7210**.

The nozzle **7240** includes a first end portion **7241** and a second end portion **7242** and wall **7251** therebetween. The first end portion **7241** includes an end surface **7249** that defines an inlet orifice **7254** configured to receive an inlet flow. The second end portion **7242** includes an end surface **7250** that defines an outlet orifice **7255**. The flow into the nozzle **7240** can include of a portion of the outlet flow of the injector **7210** and a portion of an inlet gas G_{in}. More specifically, a mixing volume **7225** is defined by a volume between the end surface **7224** of the injector **7210** and the end surface **7249** of the nozzle **7240**. The inlet gas G_{in} mixes with the partially atomized outlet flow of the solution S_{in}, further atomizing (i.e., reducing into small particles) the solution S_{in}. The concentration of the atomized solution S_{in} per volume of the air G_{in} that enters the nozzle **7240** can be adjusted by adjusting the distance D between the injector **7210** and the nozzle **7240**. For example, the distance D can be increased such that a lower concentration of the solution S_{in} per volume of the air G_{in} enters the nozzle **7240**.

Similar to the end surface **7224** of the injector **7210** described above, the end surface **7249** of the nozzle **7240** can include contours, ridges, grooves, and/or the like, configured to induce a particular fluid flow characteristic. For example, the end surface **7224** of the injector **7210** and the end surface **7249** of the nozzle **7240** can include a set of helical grooves configured to produce a rotational component in the inlet flow of the gas G_{in}. In some embodiments, the end surface **7224** of the injector **7210** and the end surface **7249** of the nozzle **7240** can be substantially flat such that any rotational component of the inlet flow of the gas G_{in} is inherent in the flow.

The inlet orifice **7254** of the nozzle **7240** receives the partially mixed combination of the solution S_{in} and the inlet gas G_{in} and can be any suitable size, shape, and/or configuration. Similar to the end surface **7224** and the end surface **7249**, the surface of the wall **7251** that defines the inlet orifice **7254** can include contours, ridges, grooves, and/or the like such as to produce a particular flow characteristic (e.g., rotational flow) to aid in the mixture of the partially atomized solution S_{in} and the inlet gas G_{in}. The interior surface of the wall **7251** of the nozzle **7240** defines a flow path **7252**. The partially atomized solution S_{in} and the inlet gas G_{in} continue to mix within the flow path **7252** while flowing toward the outlet orifice **7250** of the second end portion **7242**.

As described above, the second end portion **7242** includes the end surface **7250** that defines the outlet orifice **7255**. Similar to the outlet orifice **7218** of the injector **7210**, the outlet orifice **7255** can be any suitable orifice configured to produce an outlet flow G**1** (i.e., spray) that includes smaller particles of the solution S_{in} and the inlet gas G_{in}. In this manner, the atomizer **7200** can be considered as a two-stage atomizer **7200** such that the solution S_{in} is partially atomized when exiting the injector **7210** and further atomized when mixed with the inlet gas G_{in} within the mixing volume **7225** and the nozzle **7240** and produces an atomized mixture G**1** of the solution S_{in} and the inlet gas G_{in}.

In some embodiments, an atomizer **8200** can include an injector **8210** and a nozzle **8240**, as shown in FIG. **41**A. The injector **8210** includes a first end portion **8211** and a second end portion **8212**. The first end portion **8211** is configured to couple a supply line **8640** to the injector **8210** via the inlet line coupling **8216**. The first end portion **8211** includes an outer surface **8213** that defines a sealing groove **8215**. A sealing member (not shown in FIG. **41**A) can be configured to fit into the sealing groove **8215** to produce a substantially fluid-tight and/or hermetic seal with a component of a given housing. The injector **8210** is configured to receive the inlet flow of the solution via the supply line **8640**. The inlet flow of solution can be conveyed to the atomizer **8200** via any suitable mechanism, such as, for example, the methods described above in the water desalinization system **1000**.

The second end portion **8212** of the injector portion **8210** is configured to receive and/or be coupled to an injector insert **8219** and a mixing insert **8230**. More particularly, the injector insert **8219** is disposed within the second end portion **8212** using a threaded coupling. The outer surface **8213** at the second end portion **8212** defines a set of helical grooves **8221**, as shown in FIG. **41**A. The helical grooves **8221** are configured to produce a rotational velocity component when an inlet air flows into the atomizer **8200**, as described in more detail herein. The mixing insert **8230** includes a conical end surface **8231** and an aperture **8232** configured to receive the injector insert **8219**, as shown in FIG. **41**B. The second end portion **8212** of the injector **8210** is spaced apart from a first end portion **8241** of the nozzle **8240** by a giving distance and defines a mixing volume between the conical end surface **8231** of the mixing insert **8230** and the first end portion **8241** of the nozzle **8240**, similarly described above in the atomizer **7000**.

The injector insert **8219** defines an end surface **8224** with a solution outlet orifice **8218** substantially in the center (FIG. **41**C) and a set of smaller outlet orifices **8235** around the circumference of the injector insert **8219**, as shown in FIG. **41**D. The end surface **8224** is substantially flat and the solution outlet orifice **8218** is an extrusion (i.e., removal of material). The shape of the center outlet orifice **8218** and the set of outlet orifices **8235** can be any suitable shape such that the center outlet orifice **8218** and the set of outlet orifices **8235** can reduce the solution into an atomized flow (i.e., very small particles of the solution).

The nozzle portion **8240** includes a first end portion **8241** and a second end portion **8242**, as shown in FIG. **41**. The first end portion **8241** includes an end surface **8249** defining an opening configured to receive the atomized portion of the solution. An outer surface **8243** of the first end portion **8241** of the nozzle portion **8240** defines a set of helical grooves **8244**. The flow of the air is configured to flow within the helical grooves **8244** and into the mixing volume, described above, such that the helical grooves **8244** impart a rotational velocity component in the flow. The second end portion **8242** of the nozzle portion **8240** includes an end surface **8250** and an outlet orifice **8255**. Similar to the outlet orifice **8218** of the injector **8210**, the outlet orifice **8255** is configured to produce an outlet flow (i.e., spray) that includes smaller particles of the solution the inlet air than the inlet flow of the solution and the inlet air. In this manner, the atomizer **8200** functions similar to the atomizer **7200** described above.

FIG. **42** is a schematic illustration of an injector **9210** according to an embodiment. The injector **9210** includes a first end **9211** and a second end **9212**, an inner wall **9226** and an outer wall **9220**. The inner wall **9226** defines a first flow path **9217**. The outer wall **9220** that defines a second flow path **9227**.

The first end **9211** of the injector **9210** is configured to receive a solution S_{in}. The solution S_{in} can be any suitable solution described herein (e.g., saltwater, brackish water, etc.). The solution S_{in} can be conveyed to the injector **9210** using any suitable method, such as, for example, a supply line. The solution S_{in} can flow within the first flow path **9217** defined by the inner wall **9226** from the first end portion **9211** toward the second end portion **9212**. While indicated as forming a smooth cylindrical wall, the inner wall **9226** can form any shape with a suitable cross-sectional area. For example, in some embodiments the inner wall **9226** can form an oblong and/or non-circular cross-section. Similarly, while shown as tapering in FIG. **42**, the inner wall **9226** can have a substantially constant cross-sectional area and/or size. In some embodiments, the inner wall **9226** can define a set of grooves, such as, for example, a set of helical grooves to induce a rotational velocity component to the flow of the solution S_{in} flowing within the flow path **9217**.

The outer wall **9220** of the second end portion **9212** includes an end surface **9224** that defines a solution outlet orifice **9218**. The solution S_{in} flowing within the flow path **9217** exits the injector **9210** via the solution outlet orifice **9218**. The outlet orifice **9218** can be any suitable orifice configured to produce an outlet flow (i.e., spray) that includes smaller particles of the solution S_{in} than the inlet flow of the solution S_{in}. Similarly stated, the outlet orifice **9218** can be configured to produce at least a partially atomized flow of the solution S_{in}. Furthermore, the outlet orifice **9218** can be defined by the end surface **9224**, as described above, and in other embodiments, the outlet orifice **9218** can be a threaded insert configured to couple to the injector **9210**.

As described above, the outer wall **9220** defines a second flow path **9227** such that an inlet air G_{in} can flow within the flow path **9227** toward the end surface **9224**. The outer wall **9220** can define a set of grooves, such as, for example, a set of helical grooves to induce a rotational velocity component to the secondary flow of the inlet air G_{in} flowing within the second flow path **9227**. In this manner, the injector **9210** is configured to mix the partially atomized outlet flow of the solution S_{in} with the secondary flow of the inlet air G_{in} in a mixing volume **9225**. More specifically, the secondary flow of the inlet air G_{in} converges with the partially atomized outlet flow of the solution S_{in} at the mixing volume **9225**, thereby further atomizing the flow.

While shown and described herein as having a specific shape and configuration, the injectors, injector portions, nozzles and/or nozzle portions of any of the atomizers shown herein can be of any suitable configuration. For example, as shown in FIG. **43**, a nozzle portion **10210** can include a first end **10211**, configured to produce a flow of atomized and/or vaporized solution (not shown in FIG. **43**), and a second end **10212**, configured to receive at least a partially atomized flow of the inlet solution from an injector (not shown in FIG. **43**). For example, in some embodiments, the nozzle portion **10210** can be included within an atomizer similar to the atomizer **17200** shown and described with reference to FIG. **52**. The walls **10213** of the nozzle portion **10210** can be tapered, with a larger diameter at the first end **10211** and a smaller diameter at the second end **10212**. The second end **10212** of the injector **10210** can include an outer wall **10220** and define an outlet orifice **10218** and a set of outlet orifices **10235** disposed on the circumference of the outer wall **10220**.

The walls **10213** of the first end **10211** can include a set of inlet openings **10236** configured through which a flow of solution exits the atomizer and flows into a vaporizer and/or separator (not shown in FIG. **43**). In this manner, the first end **10211** of the injector **10210** can be configured to produce the inlet solution and the inlet air received from an injector via the orifice **10218** and the set of orifices **10235**.

FIG. **44** is a perspective view of an injector **11210**, according to another embodiment. The injector **11210** includes a first end **11211**, configured to receive an inlet solution (not shown in FIG. **44**), and a second end **11212**, configured to produce at least a partially atomized flow of the inlet solution (not shown in FIG. **44**). Similar to the injector **6210**, the first end portion **11211** includes an outer wall **11213** that defines a groove **11215** that accepts a sealing member (not shown in FIG. **44**) configured to create a fluid-tight or hermetic seal with a given housing.

The second end **11212** includes an end surface **11220** that defines a solution outlet orifice **11218**. The end surface **11220** is substantially circular with rounded edges. As shown in FIG. **44**, the solution outlet orifice **11218** is a small extrusion (i.e., removal of material) in the center of the end surface **11220** that produces the at least partially atomized flow of the solution. The solution outlet orifice **11218** is configured to have a substantially smaller diameter than the interior walls of the injector **11210**, such that a pressure is created at the interior wall of the end surface **11220** (not shown in FIG. **44**). In this manner, the solution is atomized as it exits the solution outlet orifice due to the large pressure drop upon exiting the injector.

FIG. **45** is a perspective view of an injector **12210**, according to another embodiment. The injector **12210** includes a first end **12211**, configured to receive an inlet solution (not shown in FIG. **45**), and a second end **12212**, configured to produce at least a partially atomized flow of the inlet solution (not shown in FIG. **45**). Similar to the injector **11210**, the first end portion **12211** includes an outer wall **12213** that defines a groove **12215** that accepts a sealing member (not shown in FIG. **45**) configured to create a fluid-tight or hermetic seal with a given housing.

The second end **12212** includes a tapered portion **12233** and an end surface **12220** that defines a solution outlet orifice **12218**. The tapered portion **12233** can be configured to direct a secondary flow (e.g., and airflow) toward the end surface **12220** to mix with the at least partially atomized flow of the solution. As shown in FIG. **45**, the solution outlet orifice **12218** is configured and functions similarly to the solution outlet orifice of the injector **11210**.

FIG. **46** is a perspective view of an injector **13210**, according to another embodiment. The injector **13210** includes a first end **13211**, configured to receive an inlet solution (not shown in FIG. **46**), and a second end **13212**, configured to produce at least a partially atomized flow of the inlet solution (not shown in FIG. **46**). Similar to the injector **6210**, the first end portion **13211** includes an outer wall **13213** that defines a groove **13215** that accepts a sealing member (not shown in FIG. **46**) configured to create a fluid-tight or hermetic seal with a given housing.

The second end **13212** includes an end surface **13220** that defines a solution outlet orifice **13218** and includes a raised edge **13234**, as shown in FIG. **46**. The outlet orifice **13218** receives an injector insert (not shown in FIG. **46**) that is configured to produce at least a partially atomized flow of the solution. The injector insert can couple to the solution outlet orifice **13218** in any suitable way, such as, for example, a threaded coupling. The raised edge **13234** is configured to define, at least in part, a mixing volume **13225** for the at least partially atomized flow of the solution to mix with a secondary flow of an inlet air.

FIG. **47** is a perspective view of an injector **14210**, according to another embodiment. The injector **14210** includes a first end **14211**, configured to receive an inlet solution (not shown in FIG. **47**), and a second end **14212**, configured to produce at least a partially atomized flow of the inlet solution (not shown in FIG. **47**). Similar to the injector **6210**, the first end portion **14211** includes an outer wall **14213** that defines a groove **14215** that accepts a sealing member (not shown in FIG. **47**) configured to create a fluid-tight or hermetic seal with a given housing.

The second end **14212** includes an end surface **14220**, which defines a solution outlet orifice **14218** and includes a raised edge **14234**, and defines a set of helical grooves **14221**, as shown in FIG. **46**. The outlet orifice **14218** receives an injector insert (not shown in FIG. **46**) that is configured to produce at least a partially atomized flow of the solution. The injector insert can couple to the solution outlet orifice **14218** in any suitable way, such as, for example, a threaded coupling. The helical grooves **14221** are configured induce a rotational velocity component on a secondary flow of an inlet air. The raised edge **14234** is configured to create a mixing volume **14225** for the at least partially atomized flow of the solution to mix with the secondary flow of the inlet air. The rotational velocity of the flow of the inlet air facilitates the mixing of the inlet air with the partially atomized flow of the solution, thereby further atomizing the solution.

While specific separators have been discussed herein, the systems shown and described herein can include any suitable separator. For example, FIG. **48** is a cross-sectional schematic illustration of a separator **15300**, according to an embodiment. The separator **15300** includes a housing **15310**, which can define an inlet opening **15313** and a waste outlet opening **15350**, and a separator member **15330**. The separator member **15330** includes a first end portion **15331**, which defines an inlet opening **15338**, and a second end portion **15332**, which defines a vapor outlet opening **15339**. The separator member **15330** can be configured such that an outer surface **15334** and an inner surface **15340** taper between the larger diameter of the second end portion **15332** and the smaller diameter of the first end portion **15331**, as shown in FIG. **48**.

The separator **15300** can be coupled to an outlet portion of an apparatus configured to produce a mixture G_{mix} of a gas G_{in}, a liquid portion of a solvent LIQ, a substantially vaporized portion of a solvent VAP, and a solute WASTE, such as, for example, the processor **6100** included in a water desalinization unit **6000**, as described herein. In this manner, the inlet opening **15313** receives the mixture G_{mix}, as indicated by arrow HHH. The housing **15310** includes an interior wall **15311** that can be configured to match the taper of the separator member **15330**. The tapered outer surface **15334** of the separator member **15330** defines a flow path **15337** around the circumference of the separator member **15330**, such that the more dense particles (i.e., the liquid portion of the solvent LIQ and the solute WASTE) collect on the outer surface **15334** and flow within the flow path **15337**.

With the more dense particles flowing within the flow path **15337**, the inlet opening **15338** of the separator member **15330** is configured to receive a portion of the gas G_{in} and the vaporized portion of the solvent VAP. The gas G_{in} and the vaporized portion of the solvent VAP flow within a flow path **15341** defined by the inner surface **15340** of the separator member **15330** toward the vapor outlet opening **15339**. The vapor outlet flow, indicated by arrow JJJ in FIG. **48**, includes a portion of the gas G_{in} and a vaporized portion VAP of the solvent. The vapor outlet flow can be conveyed to any suitable condenser, such that heat is removed from the vapor outlet flow in order to produce a liquid flow substantially free from the solute WASTE.

The liquid portion of the solvent LIQ and the solute WASTE flow within the flow **15337** around the circumference of the outer surface **15334** of the separator member **15330** toward the waste outlet opening **15350**. A second outlet flow includes a liquid portion LIQ of the solvent and the solute WASTE (i.e., the solid waste), indicated by arrow KKK in FIG. **48**. In this manner, the separator **15300** separates the solute from the solution. Similarly stated, in embodiments in which the solution is seawater, the separator **15300** separates the salt and/or total dissolved solids from the water, thereby producing a substantially purified water vapor.

The separator **15300** can use any suitable mechanism for separating the solute from the solution, such as a tortuous path, a filter, a rotating member, an electrically charged member and/or the like. For example, as shown in FIG. **49**, any of the separators described herein can include a separator member **16330**. The separator member **16330** includes a first end portion **16331** and a second end portion **16332**. The separator member **16330** includes an outer surface **16334**. The first end portion **16331** includes a set of protrusions **16336** that extend radially from the outer surface **16334** and define a series of channels **16335**.

The series of grooves define a flow path **16341** with a substantial rotational velocity. A mixture, such as, for example the mixture G_{mix} shown and described in FIG. **48**, can flow within the flow path **16341** such that the more dense particles of the flow are forced against the interior walls **16340** of the separator member **16330** as the mixture flows within the flow path **16341** toward the second end portion **16332**. Similarly stated, the separator member is configured to produce a centrifugal motion such that the flow within the flow path **16341** is separated between a less dense vapor portion and a more dense liquid portion. In this manner, the separator member **16330** separates the solute from the solvent, for example, if the solution is seawater, the separator member **16330** separates the salt and/or total dissolved solids from the water, thereby producing a substantially purified water vapor.

As described above with respect to FIGS. **43**-**47**, the injectors can define an outlet orifice or can include an injector insert that defines an outlet orifice. For example, FIGS. **50**A-**50**D are perspective views of various injector inserts, according to embodiments of the invention, respectively. The injector inserts can include a threaded base configured to couple the insert to the injector. The injector inserts can be any suitable size, shape, and/or configuration, such as, for example, those shown in FIGS. **50**A-**50**D. The outlet orifice defined by the injector insert can be single aperture or multiple apertures and can be configured to produce a spray including small particles of a solution.

While shown an described herein as including multiple atomizers, in some embodiments a water desalinization unit can include a single atomizer and/or vaporizer component. More specifically, a water desalinization unit can include a processor assembly that is configured to be a single stage (i.e., including one atomizer and/or vaporizer) processor. For example, FIG. **51** is a perspective view of a portion of a water desalinization unit **17000**. The water desalinization unit **17000** can include a processor assembly **17100** and an atomizer **17200**. The atomizer **17200** can be any suitable atomizer of the types shown and described herein, and can be configured to reduce a flow of a solution into small particles (i.e., produce an atomized flow of the solution). In some embodiments, the water desalinization unit **17000** can include an atomizer similar to the atomizer **8200** shown and described above. In other embodiments, the water desalinization unit **17000** can include the atomizer **17200** shown in FIG. **52**. The atomizer **17200** can function similarly to those described herein, and, as such, reduces the flow of the solution into small particles (i.e., atomized particles).

The atomizer **17200** can include any suitable injector and/or nozzle, such as those described herein. In some embodiments, the atomizer **17200** can include an injector similar to the injectors shown, for example, with respect to FIGS. **53**A-**53**C. Similarly, the atomizer **17200** can include a nozzle similar to the nozzles shown, for example, with respect to FIGS. **54**A-**54**C. In this manner, the atomizer **17200** produces an atomized flow of the solution and conveys the atomized flow to the processor assembly **17100**.

The processor assembly **17100** can include and/or employ any suitable parts, assemblies, methods, and/or the like described herein. Additionally, the processor assembly **17100** can be configured to couple to any suitable parts, assemblies, and/or the like described herein. For example, the processor assembly **17100** can be coupled to an air processing subsystem, similar in function to the air processing subsystem **6500** described with respect to FIGS. **10**-**13**. Furthermore, the processor assembly **17100** can couple to a separator, similar in function to the separator **6300** described with respect to FIGS. **30**-**39**.

While various embodiments have been described above, it should be understood that they have been presented by way of example only, and not limitation. Where methods and/or schematics described above indicate certain events and/or flow patterns occurring in certain order, the ordering of certain events and/or flow patterns may be modified. Additionally certain events may be performed concurrently in parallel processes when possible, as well as performed sequentially. While the embodiments have been particularly shown and described, it will be understood that various changes in form and details may be made.

Although the systems have been described primarily for use as water desalinization, the systems and elements thereof are not limited thereto. In some embodiments, any of the devices and/or components described herein can be used to separate a solute from any solution.

Although various embodiments have been described as having particular features and/or combinations of components, other embodiments are possible having a combination of any features and/or components from any of embodiments as discussed above.

For example, although the separator assembly **6300** is shown and described as including the first separator member **6325**, in other embodiments, any of the separator assemblies described herein can include any suitable combination of separator members described herein. For example, in some embodiments, the separator assembly **6300** can include the separator member **16330** shown and described with reference to FIG. **49**.

In some embodiments an apparatus includes an atomizer configured to mix a solution and a flow of an inlet gas to produce an atomized mixture of the solution and the inlet gas. The atomizer includes a flow member defining an outlet opening. An inner surface of the flow member defines a first flow path, and an outer surface of the flow member includes a flow structure defining at least a portion of a second flow path. The atomizer is configured to be fluidically coupled to a source of the solution such that the solution can be conveyed to from the source to the exit opening via the first flow path. The atomizer is configured such that the inlet gas can be conveyed into the first flow path via the second flow path. The flow structure configured to produce a rotational velocity component within the flow of the inlet gas when the inlet gas exits the second flow path.

In some embodiments, the flow area of the first flow path at a first location along a longitudinal axis of the flow member is different than a flow area of the first flow path at a second location along the longitudinal axis. Similarly stated, in some embodiments, the first flow path is a diverging and/or converging nozzle.

In some embodiments, the flow structure is a first vane of a set of vanes collectively configured to redirect a portion of the inlet gas within the second flow path.

In some embodiments, an apparatus includes an atomizer, a housing and a separator. The atomizer defines a liquid flow path and a gas flow path. The liquid flow path is configured to be fluidically coupled to a source of a solution such that a portion of the solution from the source of the solution can be conveyed to the atomizer via the liquid flow path. The gas flow path is configured to be fluidically coupled to a source of inlet gas such that a first portion of an inlet gas from the source of inlet gas can be conveyed to the atomizer via the gas flow path. The atomizer is configured to mix the portion of the solution and the first portion of the inlet gas to produce an atomized mixture of the solution and the first portion of the inlet gas. The housing has an inlet portion and an outlet portion, and defines a flow path between the inlet portion of the housing and the outlet portion of the housing. The inlet portion of the housing is configured to be fluidically coupled to the source of inlet gas such that a second portion of the inlet gas from the source of inlet gas can be conveyed into the flow path via the inlet portion of the housing. The atomizer is disposed at least partially within the housing such that the second portion of the inlet gas can be mixed with the atomized mixture. The separator is configured to be fluidically coupled to the outlet portion of the housing. The separator is configured to receive the mixture of the second portion of the inlet gas and the atomized mixture, and produce a first outlet flow and a second outlet flow. The first outlet flow includes a vaporized portion of a solvent from the solution. The second outlet flow includes a liquid portion of the solvent from the solution and a solute from the solution.

In some embodiments, the atomizer is one of a set of atomizers, each of which defines a liquid flow path and a gas flow path. The liquid flow path of each atomizer is configured to be fluidically coupled to the source of the solution such that the portion of the solution from the source of the solution can be conveyed in parallel to each atomizer via the liquid flow path. The gas flow path of each atomizer is configured to be fluidically coupled to the source of inlet gas such that the first portion of the inlet gas from the source of inlet gas can be conveyed in parallel to each atomizer via the gas flow path. Each atomizer is configured to mix the portion of the solution and the first portion of the inlet gas to produce an atomized mixture of the solution and the first portion of the inlet gas. Each atomizer is disposed at least partially within the housing such that the outlet portion of each atomizer is in fluid communication with the flow path. The housing is configured such that the second portion of the inlet gas can be sequentially mixed with the atomized mixture produced by each atomizer.

In some embodiments, the atomizer defines a mixing volume and is configured such that the portion of the solution is conveyed to the mixing volume via the liquid flow path and the first portion of the inlet gas is conveyed to the mixing volume via the gas flow path. A surface of the atomizer defines at least a portion of the gas flow path that is configured to produce a rotational velocity component within a flow of the first portion of the inlet gas when first portion of the inlet gas is conveyed into the mixing volume. In some embodiments, the atomizer includes an injection member and an outlet nozzle. The injection member defines a mixing volume such that the portion of the solution is conveyed to the mixing volume via the liquid flow path. The outlet nozzle is spaced apart from the injection member such that the outlet nozzle and the injection member collectively define the gas flow path. The first portion of the inlet gas is conveyed to the mixing volume via the gas flow path.

What is claimed is:

1. An apparatus, comprising:

an atomizer configured to mix a solution and a flow of an inlet gas to produce an atomized mixture of the solution and the inlet gas, the atomizer including a flow member defining an outlet opening, an inner surface of the flow member defining a first flow path, an outer surface of the flow member including a vane defining at least a portion of a second flow path,

the atomizer configured to be fluidically coupled to a source of the solution such that the solution can be conveyed to the source to the outlet opening via the first flow path, the atomizer configured such that the inlet gas can be conveyed into the first flow path via the second flow path, the vane configured to redirect a portion of at least one of a tangential velocity component or a circumferential velocity component of the flow of the inlet gas when the inlet as flows within second flow path to produce a rotational velocity component within the flow of the inlet gas when the inlet gas exits the second flow path; and

a separator configured to be fluidically coupled to the outlet opening of the atomizer, the separator configured to receive the mixture of the inlet gas and the solution, the separator configured to produce a first outlet flow and a second outlet flow, the first outlet flow including a vaporized portion of a solvent from the solution, the second outlet flow including a liquid portion of the solvent from the solution and a solute from the solution.

2. The apparatus of claim **1**, wherein a flow area of the first flow path at a first location along a longitudinal axis of the flow member is different than a flow area of the first flow path at a second location along the longitudinal axis.

3. The apparatus of claim **1**, wherein the first flow path diverges along a longitudinal axis of the flow member.

4. The apparatus of claim **1**, wherein the flow member is a receiving nozzle, the apparatus further comprising:

an injector configured to produce a spray of the solution into the receiving nozzle, the injector defining a mixing volume within which the solution and the inlet gas are mixed.

5. The apparatus of claim **4**, wherein an outlet portion of the injector is spaced apart from an inlet portion of the receiving nozzle.

6. The apparatus of claim **1**, wherein the second flow path surrounds at least a portion of the first flow path.

7. The apparatus of claim **1**, wherein the separator includes a separator member disposed within a housing, separator member defining a central opening and having an outer surface defining a plurality of grooves configured to direct the first outlet flow towards the central opening.

8. The apparatus of claim **7**, wherein the housing defines a waste opening offset from the central opening, the plurality of grooves configured to configured to direct the second outlet flow towards the waste opening.

9. An apparatus, comprising:

an atomizer assembly configured to mix a solution and a flow of an inlet gas to produce an atomized mixture of the solution and the inlet gas, the atomizer assembly including a flow member, an inner surface of the flow member defining a first flow path, an outer surface of the flow member including a vane defining at least a portion of a second flow path,

the atomizer assembly configured to be fluidically coupled to a source of the solution such that the solution can be conveyed to from the source via the first flow path, the atomizer configured such that the inlet gas can be conveyed into the first flow path via the second flow path, the vane configured to redirect a portion of at least one velocity component of the flow of the inlet gas when the inlet gas flows within second flow path to produce a rotational velocity component within the flow of the inlet gas when the inlet gas exits the second flow path; and

a separator configured to be fluidically coupled to the outlet opening of the atomizer assembly such that the separator is configured to receive the mixture of the inlet gas and the solution and produce a first outlet flow and a second outlet flow, the first outlet flow including a vaporized portion of a solvent from the solution, the second outlet flow including a liquid portion of the solvent from the solution and a solute from the solution, the separator including a separator member disposed within a housing, separator member defining a central opening and having an outer surface defining a plurality of grooves configured to direct the first outlet flow towards the central opening.

10. The apparatus of claim **9**, wherein the housing defines a waste opening offset from the central opening, the plurality of grooves configured to configured to direct the second outlet flow towards the waste opening.

11. The apparatus of claim **9**, wherein the atomizer assembly includes an injector configured to produce a spray of the solution into the first flow path.

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